Final Technical Report

Michael J. Warnock (compiler)
Texas Research Institute for Environmental Studies
Sam Houston State University

SERDP Project Number CS-1068
P Number 96pr06634-02
ONR Grant Number N000149611067
ORNL Contract Numbers 17X-SW479C and 28X-SW479C

5 May 1998

19980908 005

Environmental activity cost analysis
Executive Summary

PLEASE CHECK THE APPROPRIATE BLOCK BELOW:

☐ ___/___ copies are being forwarded. Indicate whether Statement A, B, C, D, E, F, or X applies.

☒ DISTRIBUTION STATEMENT A:
APPROVED FOR PUBLIC RELEASE: DISTRIBUTION IS UNLIMITED

☐ DISTRIBUTION STATEMENT B:
DISTRIBUTION AUTHORIZED TO U.S. GOVERNMENT AGENCIES ONLY; (Indicate Reason and Date). OTHER REQUESTS FOR THIS DOCUMENT SHALL BE REFERRED TO (Indicate Controlling DoD Office).

☐ DISTRIBUTION STATEMENT C:
DISTRIBUTION AUTHORIZED TO U.S. GOVERNMENT AGENCIES AND THEIR CONTRACTORS; (Indicate Reason and Date). OTHER REQUESTS FOR THIS DOCUMENT SHALL BE REFERRED TO (Indicate Controlling DoD Office).

☐ DISTRIBUTION STATEMENT D:
DISTRIBUTION AUTHORIZED TO DOD AND U.S. DOD CONTRACTORS ONLY; (Indicate Reason and Date). OTHER REQUESTS SHALL BE REFERRED TO (Indicate Controlling DoD Office).

☐ DISTRIBUTION STATEMENT E:
DISTRIBUTION AUTHORIZED TO DOD COMPONENTS ONLY; (Indicate Reason and Date). OTHER REQUESTS SHALL BE REFERRED TO (Indicate Controlling DoD Office).

☐ DISTRIBUTION STATEMENT F:
FURTHER DISSEMINATION ONLY AS DIRECTED BY (Indicate Controlling DoD Office and Date) or HIGHER DOD AUTHORITY.

☐ DISTRIBUTION STATEMENT X:
DISTRIBUTION AUTHORIZED TO U.S. GOVERNMENT AGENCIES AND PRIVATE INDIVIDUALS OR ENTERPRISES ELIGIBLE TO OBTAIN EXPORT-CONTROLLED TECHNICAL DATA IN ACCORDANCE WITH DOD DIRECTIVE 5230.25, WITHHOLDING OF UNCLASSIFIED TECHNICAL DATA FROM PUBLIC DISCLOSURE, 6 Nov 1984 (Indicate date of determination). CONTROLLING DOD OFFICE IS (Indicate Controlling DoD Office).

☐ This document was previously forwarded to DTIC on ____________ (date) and the AD number is ________________.

☐ In accordance with the provisions of DoD instructions, the document requested is not supplied because:

☐ It is TOP SECRET.

☐ It is excepted in accordance with DoD instructions pertaining to communications and electronic intelligence.

☐ It is a registered publication.

☐ It is a contract or grant proposal, or an order.

☐ It will be published at a later date. (Enter approximate date, if known.)

☐ Other. (Give Reason.)

Ross Quarles
Print or Typed Name

Ron Quarles
Authorized Signature Date

409-294-1258
Telephone Number

Yes etc

Final Technical Report

Michael J. Warnock (compiler)
Texas Research Institute for Environmental Studies
Sam Houston State University

SERDP Project Number CS-1068
P Number 96pr06634-02
ONR Grant Number N000149611067
ORNL Contract Numbers 17X-SW479C and 28X-SW479C

5 May 1998

Final Technical Report
Contents

Final Technical Report

SERDP Project Number CS-1068
P Number 96pr06634-02

Section I
Environmental Cost Accounting Methodology
ONR Grant Number N000149611067 (in part)

Dr. Ross Quarles

Texas Research Institute for Environmental Studies
College of Business Administration
Department of Accounting
Sam Houston State University

Holston
Environmental Activity Cost Analysis
Executive Summary

Texas Regional Institute for Environmental Studies
Ross Quarles, Project Manager
December 15, 1997

This report presents the findings of the second phase of a three-phase process to develop a method of detailed environmental cost analysis to support the concepts of environmental Life Cycle Analysis (LCA). LCA is an EPA-recognized, high-level, macro approach for analysis of environmental issues over the cradle to grave life cycle of a product or process. LCA lacks, however, a method for micro-level analysis of specific detailed private environmental cost incurred in the operations of an organization in meeting environmental requirements. If LCA is to be successful, these private costs of organizational environmental activities must be quantified for each functional area and then summed to provide total private environmental cost involved in creation of a product or operation of a system. Existing systems of cost analysis are generally incapable of providing the detailed environmental cost information to support LCA and ensure its linkage to the operational world. This report describes an environmental cost analysis process that overcomes these shortcomings of existing cost analysis systems.

In the first phase of this research, a research team from the Texas Regional Institute for Environmental Studies (TRIES) developed a method that can be used for detailed micro-level analysis of environmental costs. That method, Environmental Activity Cost Analysis (EACA), is based on the concepts of Activity Based Costing (ABC) and uses Environmental Activity Storyboarding, a process developed in this research project to identify and quantify the costs of individual environmentally driven job tasks and activities. In a prior study, the EACA method was applied to a single product over multiple life-cycle stages in order to test the method's capacity to identify private environmental costs across life cycle stages. In the current research project, EACA was applied to a single life cycle stage, manufacturing, in a multi-product setting to test the capacity of the method to differentiate individual private environmental costs among those products. The third phase should test EACA across life-cycle stages in multi-product settings.

The operations of the Holston Defense Corporation at the Holston Army Ammunition Plant in Holston, Tennessee provided the research setting for the application of the EACA process in this research. During the six-month period ending June 30, 1997 to which the EACA method was applied at Holston, production consisted primarily of eight prime contract energetic products all using basically the same manufacturing processes, workforce, and facilities. The Environmental Storyboarding process obtained inputs from individuals with a total of 2,561 years experience in operations at Holston. The specific findings in regard to Holston are identified in the following paragraphs.

- Of the $22,240K total of all activity and job-task costs incurred at Holston, $3,146K or 14.1% were environmental costs. These costs would not, theoretically, have been incurred in the absence of environmental requirements.

- Of the $16,325 of activity and job-task costs incurred at Holston specifically in the production of eight prime contract energetic products, $2,781 or 17% were driven by environmental requirements. This indicates that 17% of the cost of the eight products produced is incurred solely due to environmental requirements.

- Of the $3,146K of environmental costs of all activities at Holston, 49% were for preventive activities, 6% were for detecting activities, 6% for correcting activities, 22% involved disposal activities, and 17% were for reporting activities. This high percentage in the preventive area may be due in part to the nature of the materials, processes, and products at Holston. It may also be affected by the maturity and stability of the operations that have allowed operations to evolve that foster planning as opposed to reacting to highly volatile situations.

- Of the $3,146K of environmental costs of all activities at Holston, 18% of those costs were incurred directly in the production functional area while 23% were incurred in the production support function, 24% were in the maintenance function, and 34% were in the general support area. The presence of significant levels of environmental cost in non-production or overhead areas supports the need for the examination of all functional areas of an organization in environmental cost analysis.

- The eight primary products produced at Holston during the period represented basically two families of products – HMX-based and RDX-based. Regarding the environmental product cost within each of those families, the two RDX-based products were slightly lower in total environmental cost as a percent of total product cost (average of 16.6%) than were the six HMX-based products (average of 17%).

- When the categories of environmental cost incurred were considered in relation to the individual Holston products, significant differences in the types of expenditures between the two families were found. For example, prevention activity costs for RDX-based products averaged 36.7% of product environmental costs while prevention activities for HMX-based products averaged 50.4% of environmental product cost. The differences in all of the various environmental product cost categories between the two families are shown below.

	Average as a % of Total Environmental Cost	
Environmental Cost Category	**RDX-based Products**	**HMX-based Products**
Prevention	*36.7%*	*50.4%*
Disposal	*28.1%*	*22.6%*
Reporting	*21.6%*	*15.7%*
Detection	*7.8%*	*5.9%*
Correction	*5.9%*	*5.5%*

There are a number of implications from the results of this study regarding future research in this area.

- The EACA method successfully differentiated among functional area environmental costs and among product specific environmental costs in the multi-product setting at Holston even though the products created and processes used were highly similar. This suggests that the method should be applied in new settings to further test its robustness in providing detailed, activity level private environmental cost information.

- The differences in types of environmental costs between families of products suggest that the type of environmental activities associated with products are potentially formula or composition driven rather than process or operation driven. This suggests that when environmental activities are being planned as factors in new product or process development, both the formulas of the products as well as the processes through which they will pass should be considered as environmental activity cost drivers.

- The significant presence of environmental costs in overhead functions suggests that any environmental activity analysis or planning must consider all functional areas of an organization, not simply direct production areas. The fact that in many cases overhead or non-production functional areas provide intangible services will not make this task any easier. Application of methods such as EACA may be necessary to establish benchmarks for environmental costs present in these overhead service-type functional areas.

- The maturity and stability of the products and operations at Holston suggest that the Holston findings may be a potential environmental cost benchmark against which the environmental costs of new processes and products in the same generic area can be evaluated. The comparatively high level of environmental expenditures on preventive activities may be a result of this maturity and stability and potentially serve as a target for planning in new product or process development.

Holston
Environmental Activity Cost Analysis
Report

Texas Regional Institute for Environmental Studies

Ross Quarles, PhD, CPA
Project Manager

December 15, 1997

I. Introduction

This report discusses the results of the second phase of a three-phase process necessary to develop an operational level cost analysis methodology to support Environmental Life Cycle Analysis for decision making regarding environmental issues. The three phases and their scopes are discussed in section III below.

II. Purpose and Need

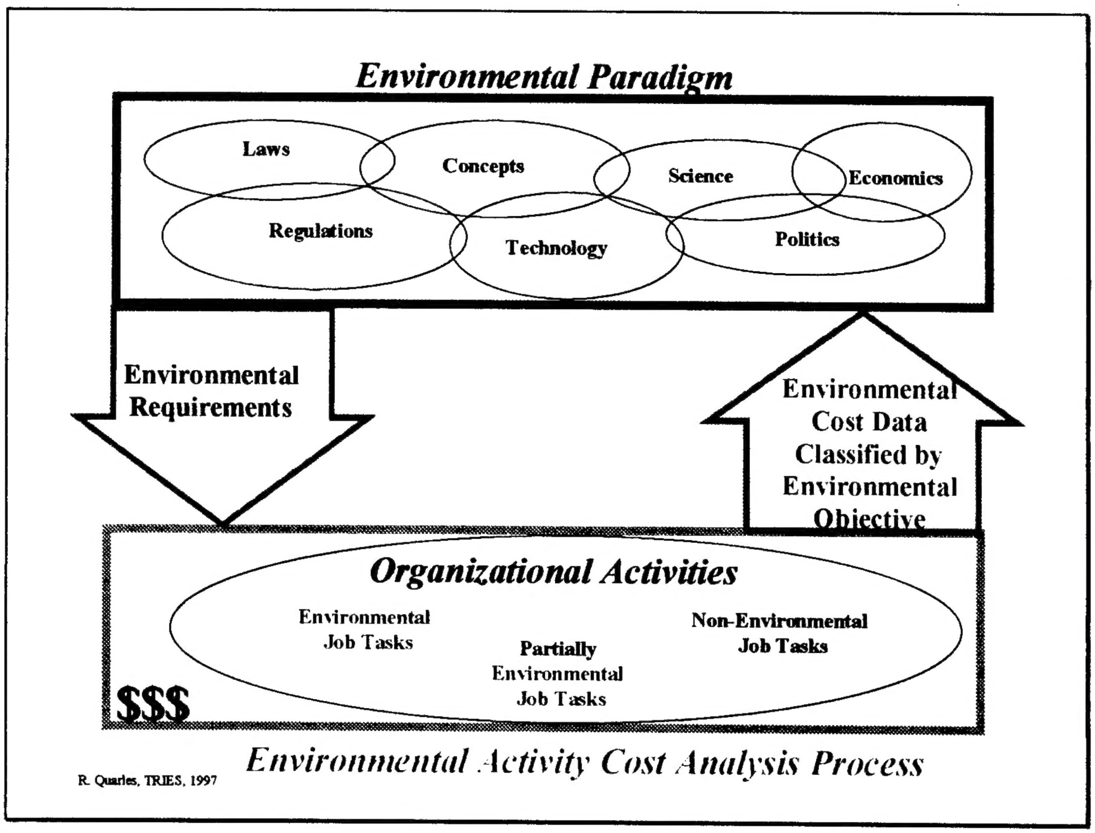
The overall purpose of this study is to develop an organizational activity level environmental cost analysis method that can be used to provide specific private[1] environmental cost information for decision making within each phase of the Life Cycle Analysis process.

As a high level or macro model sanctioned by the EPA, Life Cycle Analysis (LCA) provides the conceptual framework necessary to examine environmental cost over the life of a product or system. The conceptual constructs of the LCA model, however, do not provide a micro or detailed operational cost analysis method that can be used to identify and quantify specific environmental costs. The absence of detailed environmental cost information is a shortcoming of the LCA model that must be overcome if that model is to reach its full potential in addressing environmental issues. Therefore, some method must be developed to quantify private environmental costs at the detailed organizational activity level. Decision makers using the environmental paradigm to shape their view of environmental issues create environmental requirements that affect the detailed activities of organizations. Addressing environmental costs at the detailed organizational activity level is therefore necessary because it is at that level where

[1] The EPA [1995] has distinguished between private environmental costs and public or societal environmental cost by defining the former as costs that business incurs or for which it can be held accountable. As stated by the EPA, these private costs directly affect a firm's bottom line.

costs are incurred in order to meet the environmental requirements levied on organizations.

As shown in the following graphic, the environmental paradigm represents the combination of the numerous factors that affect how society views and deals with environmental issues. The states of science and technology at a given point in time affect how environmental issues are framed for reference. Politics, economics, tradition, and custom are additional factors that affect how environmental issues are viewed. Existing laws and regulations affect the focus of the environmental paradigm at any given point in time and serve as a frame of reference for the future. All of these factors working in concert shape the view of environmental issues by society and society's decision makers. That view is manifest in the environmental requirements that face organizations in regard to both general and specific environmental issues. These environmental requirements, whether in the form of specific laws, regulations, etc. or in the form of general expectations and guidelines, dictate how an organization must carry on its operational activities.



The environmental requirements emerging from the paradigm necessitate that an organization tailor its operations and activities to meet those requirements. Some organizational activities may be carried out solely due to environmental requirements while other activities may only be done in part due to environmental

requirements. In addition there are, of course, organizational activities that have nothing to do with anything environmental. In the case of activities that are driven solely by environmental requirements, identification and quantification of the direct private costs of those activities represent relatively simple tasks using existing accounting and cost information analysis methods. However, even if a given activity is completely driven by environmental requirements, the quantification of only its direct cost with no recognition of its potentially substantial indirect costs may significantly understate the full private cost of the activity. In addition, in cases where a given organizational activity is in part accomplished due to environmental requirements and in part done for operational or business reasons, the costs associated with the activity must be broken down to reflect environmental and non-environmental portions.

Specifically how environmental requirements affect the activities of an organization is a problematic issue given the absence of any method to analyze those activities in detail to determine their environmental content. What is clearer, however, is that environmental requirements cause an organization to incur incremental private costs in meeting the provisions of those requirements. Even though there may be general agreement on this latter point, there is no quantification of the incremental cost incurred nor is there any feedback mechanism to provide a measure of that cost as an additional factor to be considered in the environmental paradigm. The absence of a feedback mechanism creates a situation in which the factors of the environmental paradigm act to create environmental requirements necessitating that organizations incur compliance costs but the magnitude of those costs is not a part of the decision making process, either before or after the fact. This may lead to an environmental decision making cost information vacuum in which the total operational activity cost necessary in meeting the requirements of decisions regarding environmental issues is not known. A fully developed process through which decisions are framed should possibly include a feedback mechanism to provide an indication of the cost effects of environmental requirements on the operational activities of organizations that must meet those requirements. While the identification and quantification of these costs are consistent with the concepts of LCA, existing accounting and cost analysis methods do not provide the detailed organizational activity environmental cost analysis method necessary to accomplish those tasks. The environmental cost analysis method developed in this project and described in this report is, however, suggested as a new method that can serve as a subprocess to potentially provide detailed organizational activity environmental cost data to the overall LCA process. This new method is defined as Environmental Activity Cost Analysis (EACA) and was used to analyze the private environmental cost of production operations of the Holston Defense Corporation at Holston Army Ammunition Depot.

III. Phases of the Overall Study

The three phases required to develop and test the viability of the EACA method are described in the following paragraphs.

Phase 1: Single Product/Across Life Cycle Stages

Develop the basic Environmental Activity Cost Analysis method for the single output product or service situation and test that process across multiple steps in the life cycle of a single product or system. In essence this phase involved the development of the initial method and testing it "longitudinally" across multiple life cycle phases of a single product or system. This phase was completed in the SADARM environmental cost analysis project sponsored by the US Army PBMA and the Army Research Office. The success of this phase of the overall project provided the basic framework for the EACA method and indicated its viability and applicability for the determination of the environmental costs associated with a single product or system across multiple phases of the life cycle. This step did not, however, demonstrate the applicability of the method in cases where numerous products are created or multiple systems operated within a given set of organizational functions (i.e., the multiple product or system situation).

Phase 2: Multiple Product/Services Within a Single Life Cycle Stage

This phase involves enhancing the EACA method to address the multiple products or system situation in which there are numerous end products or systems produced through the activities of functional organizational units. Exercising the enhanced methodology in this multiple product or system operational environment demonstrates its capacity to differentiate between the different environmental costs being incurred to support the production of numerous products or systems. By necessity, this phase concentrated on the multiple product or system circumstances within a single phase of the life cycle (i.e., manufacturing) and exercised the method "vertically" within that phase. This phase has been completed and is the subject of the Holston Defense Corporation Environmental Activity Cost Analysis report sponsored by SERDP and administered by the Office of Naval Research.

Phase 3: Multiple Products/Services Across Multiple Life Cycle Stages

The final phase necessary for overall development of the EACA method will exercise the method across the identified phases of the life cycle of a product or system that is a part of organizational activities that produce or service many products or systems. This multiple

product/system, multiple life cycle phase study will fully exercise the method both "longitudinally" and "horizontally" across multiple products or systems operations and across multiple life cycle phases. The magnitude of this study will of course dictate that it involves a much longer time line and interaction with more organizations and functions than did either of the preceding phases.

IV. Background of the Current Study

In order to complete Phase 2 of development of the EACA method, cooperation and participation were required from an organization that produced numerous products and which faced substantial environmental requirements. Holston Defense Corporation (HDC) agreed to be the test site for this phase of the study.

HDC is the operating contractor for the Holston Army Ammunition Plant (HAAP). HDC is a subsidiary of Eastman Chemical Company. HDC produces families of products based on High Melting Explosive (HMX) and Research Department Explosive (RDX) which are energetic materials for use in explosives and rocket propellants. HAAP was originally built during World War II to produce the large quantities of RDX needed to counter the Nazi submarine threat. RDX was much more potent than TNT against Nazi "supersubs". By January 1944 HAAP was producing and shipping about 570 tons a day of "Composition B."

Primary raw materials are nitric acid-ammonium nitrate solution, hexamine-acetic acid solution, and acetic anhydride. These are mixed in a nitration operation. The nitration operation is common to both RDX and HMX. Differentiation is dependent on the proportions of raw materials and process time and temperature. Further processing involves recovering the RDX/HMX, recrystallizing, purifying, and drying. Other materials including TNT, wax, and other binders are incorporated to stabilize and provide unique performance characteristics.

Appendix D of the report contains materials provided by the Holston Army Ammunition Plant that fully describe the history, products, and operations at Holston.

V. Methodology

The theoretical background and full details concerning the method of Environmental Activity Cost Analysis developed and exercised in this study are provided in Appendix B of this document.

The concepts of Activity Based Costing (ABC) provide the framework for the EACA method developed in this study and used to identify and quantify the environmental costs incurred in the operations and creation of products by HDC. Under the ABC view, resources are consumed by activities and activities are used to serve cost objects. By identifying the cause and effect consumption relationships

between resources and activities (resource drivers) and the cause and effect usage relationships between activities and cost objects (activity drivers), an accurate cost of the resources consumed can be tied to cost objects produced. This cause-and-effect based cost quantification is superior to the arbitrary cost allocation schemes of traditional accounting.

The general ABC cost analysis process can be focused to examine unique classifications of drivers and cost relationships that are caused by specific requirements such as environmental, safety, regulatory, or other issues. In the current study, the ABC process was used to focus on the environmental costs incurred in the manufacture of energetics due to the requirements generated by the combined elements of the environmental paradigm.

A process of Environmental Activity Cost Analysis (EACA), based on the ABC framework, was developed for use in this project. This process is basically identical to the ABC analysis process but with an added dimension to address environmental costs. The EACA process is the result of extensions and improvements made to a bottoms-up or job task driven environmental cost analysis process initially developed in a project sponsored by the US Army (1994] to address internal environmental costs over the life cycle of a proposed weapon system. This EACA process utilizes an interactive modified Delphi-like group participation process developed as part of this research project and defined as Environmental Activity Storyboarding. The storyboarding process utilizes a focus group or panel who are experts on the functional area under examination. These experts are those individuals (or a representative sample) who work in an area and actually perform the tasks carried out within that organizational function. There were twenty-six sessions held at Holston with one hundred fourteen participants. The total experience represented by these participants was 2,561 years of operational experience at Holston.

The complete EACA process consists of a number of steps designed to obtain data concerning the various elements that are used to develop a model of the environmental cost of organizational units and individual products. These steps include:

1. identification of organizational resources consumed by the organizational unit under examination,
2. identification of job tasks and activities performed that consume organizational resources,
3. identification and quantification of resource drivers that measure resource consumption by job tasks,
4. identification of cost objects served by activities and activity drivers that measure activity consumption,
5. identification of environmental job tasks,
6. classification of environmental job tasks by environmental objective,

7. calculation of resource consumption by job task based on resource drivers,
8. calculation of organizational unit environmental cost in total and by environmental classification,
9. calculation, for multiple product or service organizational units, of the environmental cost by product/service using activity drivers,
10. calculation, for multiple product or service organizational units, of the environmental cost of each product/service by environmental classification.

These steps are completed for each functional area in the organization. When analysis of all functions is completed, the activity driven cost of each cost object served by the total organization is determined by summing the individual unit data. [See Appendix B for a full discussion of how each of these steps is implemented in conducting this study].

VI. Holston Resources, Activities, and Products (Cost Objects)

The EACA method developed in this study is a specialized application of the Activity Based Costing framework. In keeping with that framework, the method requires the identification of the resources, activities, and cost objects (i.e., products) and linkages between these elements that are present in the process under examination. The paragraphs below identify and discuss each of these elements identified in the application of EACA to the Holston Defense Corporation operations.

A. Resources

Resources are the factors that allow the productive activity necessary to create products or serve customers. Resources include labor, technology, travel, supplies, etc. that are consumed in carrying on activities. Resources are measured in terms of their costs to the organization. These resource costs are accumulated in the general ledger of the firm and are traced or allocated to products under traditional costing systems. Under the ABC approach, the resource costs accounts are reclassified from general ledger accounts into resource categories related to activities rather than to accounting classifications. This reclassification "unbundles" resource costs from the ledger accounts and restates them according to how the resources are consumed. It also allows identification of resource drivers that link each resource category to the particular activities in which they are consumed. A resource driver is a factor that best relates the use of the resource to an activity and in many cases represents the direct cause of changes in resource costs. The reclassification process also results in the elimination of some general ledger costs recorded due to accounting requirements but that are not related to the current activities or operations of the entity. For example, the cost of past service retirement benefits is recorded in the general ledger but may not be related to current operations.

Holston Defense Corporation incurred costs of $30.9 million (excluding raw materials) during the six-month period ending June 30, 1997. Of this total, $6.8 million was for costs (i.e., Retiree Benefits and Termination Allowances) not directly pertinent to this study. Also included in that total cost was $1.9 million for indirect materials consumed in production. The costs of these indirect materials (e.g., solvents, tags, etc.) were excluded from the analysis of environmental costs for the same reasons that the costs of raw materials were excluded. The reconciliation of the Holston operating costs for the first six months of 1997 is shown in Figure 1 below.

Holston: Figure 1
Environmental Activity Cost Analysis
Total Cost Reconciliation
Six Month Period Ending 06/30/97 ($ 000)

Total Cost			$ 30,913
Less:			
Non-Production Costs			
Retiree Benefits	6,510		
Termination Allowance	272		
	--------	6,782	
Indirect Materials		1,891	8,673
		--------	--------
Cost of Job Tasks and Activities Analyzed			$ 22,240

In the Holston study, the ultimate objective was to identify environmental costs associated with operations involved in production of energetic materials. Therefore, only environmental costs incurred at Holston were of concern for this study. For this reason, costs of raw materials used in Holston operations were not considered as one of the resources to be tracked. Any environmental costs included in the cost of raw materials used at Holston are included in the price paid by Holston Defense Corporation to suppliers. Environmental costs incurred by those suppliers were beyond the scope of the Holston study.

The resource cost categories identified and reclassified in the analysis of the Holston operating ledger are shown in Figure 2 below.

Holston: Figure 2
Environmental Activity Cost Analysis
ABC Resource Categories

Labor	Subcontractors	Travel
Employee Benefits	Training	Planning
Maintenance	Permits	

B. Activities

Activities are the things that people and equipment do to satisfy customer wants and needs. Activities are things an organization spends its time doing and which consume resources of the organization. Activities are the units of work going on in the organization. A given activity may involve a number of individual but related job tasks. Activities are carried out primarily for two reasons: (1) as part of the process that directly creates a product or provides a service to a customer or (2) as part of a sustaining process that supports and helps operate all production or service processes in the organization.

At Holston, two hundred seven unique activities in twenty-four functional areas were identified in conjunction with this study. These activities represent those things that are accomplished in order to support cost objects or products involved in Holston operations. These activities, the job tasks of which they are composed, and the functional areas in which they occur are identified in Appendix C of this report. Those activities that do not directly support cost objects but are required in order to maintain facility or plant level operations (i. e., sustaining activities) were also identified. These sustaining activities and their costs are shown in Figure 3 that follows.

Holston: Figure 3
Environmental Activity Cost Analysis
Sustaining Activity Totals
Six Month Period Ending 06/30/97 ($000)

Road and Grounds Maintenance	$ 418
Planning	177
Other Facility and Property	130
Accounting	86
Information Systems	695
Management	838
General Taxes & Insurance	1,448

Total	$ 3,992

C. Products (Cost Objects)

Cost objects in the ABC framework are the end products or customer services that are the outcomes of activities. Activities are carried out in order to support these cost objects or products. Cost objects are the things for which measurements of cost are desired. Cost objects make demands on or consume the activities of the organization. The linkages between cost objects and activities

through which demand or consumption is directed are known as activity drivers. These drivers may be based on volume of production, number of setups, number of people, batches, steam usage, square feet occupied, etc.

The activities at Holston are carried out in order to support a number of cost objects including specific HMX and RDX based products and special order one-time contract requests. These special order requests are tracked in a job-cost type manner and their costs are separately identifiable from those of the production of the primary energetics products. Given the erratic, one-time nature of these one-time contract activities and the intent of this study to examine recurring operations, the costs of these contract activities were not analyzed as to their environmental content or purpose. This elimination resulted in the identification of eight individual products that were produced in quantity at Holston during the six-month period under examination. Six of the products were RDX-based and two were HMX-based. These products are shown in Figure 4.

Holston: Figure 4
Environmental Activity Cost Analysis
Recurring Production Products
Six Month Period Ending 06/30/97

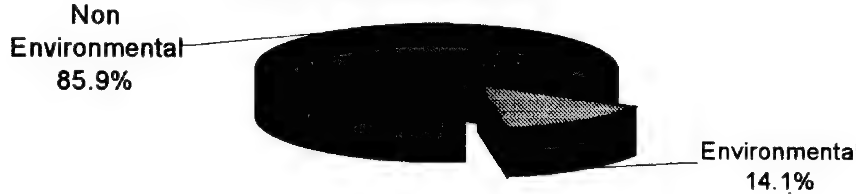
4113 COMP C-4 CL.3 W/TAGN	RDX Based
4388 CMX-3 (RDX/DOM)	
4530 OCTOL 75/25 TYPE 1	HMX Based
4582 PBXN-5, TYPE II, CL 3	
4585 PBXN-9	
4715 LX-14-0	
4992 HMX, GRADE B, 80S	
4920 HMX, GRADE B, CL 1	

VII. Holston Findings and Discussion

A. Total Environmental Cost

As shown in Figure 6 below, the total environmental cost of all activities analyzed at Holston was $ 3,146K out of the total of $22,240K incurred. This represents 14.1% environmental costs involved in carrying on the activities at Holston during the first six months of 1997.

Holston: Figure 5
Environmental Activity Cost Analysis
Total Environmental Cost



Green/Non Green	$ 000's
Environmental	3,146
Non Environmental	19,094
Total Job Task cost	*22,240*

B. Total Environmental Cost by Environmental Objective Category

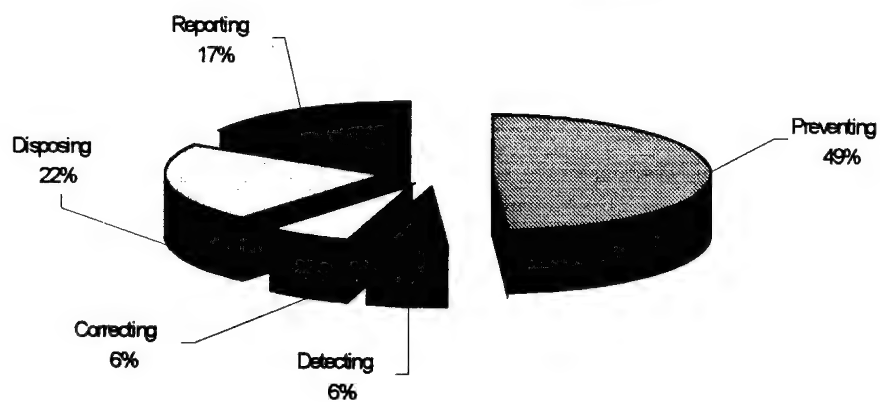
In order to fully analyze the environmental cost incurred, the Environmental Storyboarding Process includes a process through which the nature of the environmental activities their costs are identified based on the environmental objective associated with carrying each such activity. An environmental objective, as defined in this process, is the reason why the activity is being performed. The figure below provides a brief explanation of each of the environmental objectives used in this study. A full definition and discussion of the importance of these environmental objectives is contained in Appendix B of this report.

Holston: Figure 6
Environmental Activity Cost Analysis
Activity Based Environmental Objective Definitions

Preventing	Disposing	Detecting	Correcting	Reporting
Tasks performed to prevent or deter adverse environmental conditions, events, or consequences.	Tasks performed to dispose of materials or products in an environmentally benign or proper manner.	Tasks performed to determine if an environmentally adverse condition or event has occurred or is occurring.	Tasks performed to remedy or mitigate the existence or effects of an environmentally adverse condition or event.	Tasks performed to comply with regulatory reporting and record keeping requirements.

As shown in Figure 7 that follows, the major environmental cost category at Holston was prevention, with 49% of all environmental costs being directed to this objective. Disposal activities represent the next highest cost with 22%; reporting activities consume 17% of the total environmental costs; and detecting and correcting each consumes 6%.

Holston: Figure 7
Environmental Activity Cost Analysis
Environmental Costs by Category

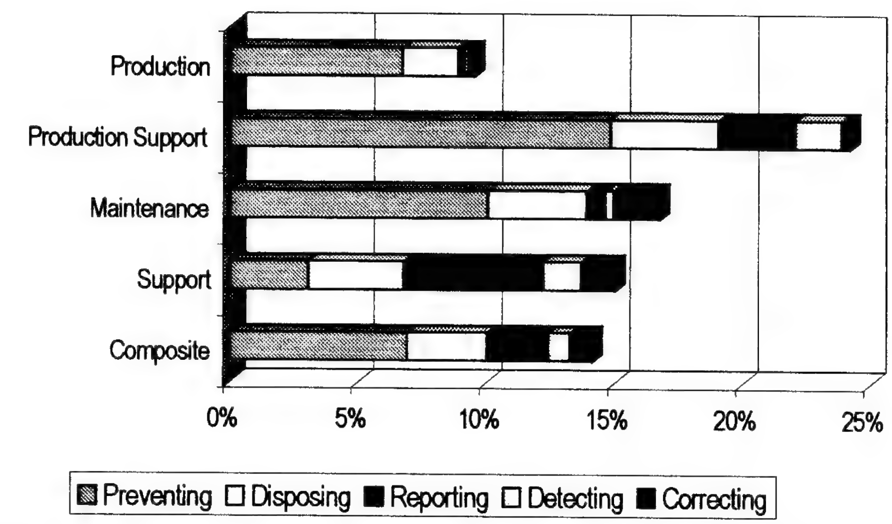


Category	$ 000's	% of Environmental	% of Total
Preventing	1,537	49%	7%
Detecting	187	6%	1%
Correcting	199	6%	1%
Disposing	699	22%	3%
Reporting	523	17%	2%
Total Environmental	3,146	100%	14%
Non Environmental	19,094		86%
Total	22,240		100%

C. Environmental Cost by Functional Organizational Area

One consideration in regard to environmental cost analysis is that differing areas of operations may have diverse environmental cost elements and considerations. In order to analyze the environmental costs at Holston to address this consideration, the data for individual functional areas of the Holston operations were rearranged based on type of functional area. Four functional categories were determined to be applicable for this process, including: Production, Production Support, Maintenance, and General Support. The environmental cost incurred, by environmental objective, for each of these functional areas is shown in Figure 8 below. As indicated in the graphic, the Production Support area has the highest percentage of environmental cost.

Holston: Figure 8
Environmental Activity Cost Analysis
Environmental Cost by Functional Area



Organization	Preventing	Detecting	Correcting	Disposing	Reporting	Total
Composite	**7%**	**1%**	**1%**	**3%**	**2%**	**14%**
Support	3%	2%	1%	4%	5%	15%
Maintenance	10%	0%	2%	4%	1%	17%
Production Support	15%	2%	0%	4%	3%	24%
Production	7%	0%	0%	2%	0%	10%

As shown in Figure 9 on the following page, 24% of all activity costs within the Production Support area are driven by environmental requirements. Also, 17% of the activity cost within the Maintenance area and 15% of the activity cost within the Support area are environmentally driven. Individually, each of these percentages exceeds the environmental cost percentage in the Production area. These significantly higher environmental costs as a percentage of total costs within the three "overhead" functions support the EPA argument that overhead functional areas are potentially important contributors to total environmental cost.

Holston: Figure 9
Environmental Activity Cost Analysis
Organizational and Functional Area Cost Data
Six months ended June 30, 1997

ORGANIZATIONAL AREA/UN	$ Prevent	$ Detect	$ Correct	$ Dispose	$ Report	Total $ Environ	Total $ Activities	% Environ
PRODUCTION AREA								
Organic Acids	162,826	0	0	60,076	14,384	237,286	1,000,751	24%
Area B Acids	156,299	0	1,528	9,170	357	167,353	937,197	18%
Explosives Manufacturing	57,083	5,121	8,370	47,005	1,334	118,914	2,277,551	5%
Explosives Finishing/Mat. Handling	33,047	4,374	3,828	14,873	0	56,122	1,869,018	3%
Total Area $	409,256	9,495	13,725	131,124	16,075	579,675	6,084,516	10%
% of Total Area	70.6%	1.6%	2.4%	22.6%	2.8%			
Area % of Total Env $ and Total Activity $						18%	27%	
PRODUCTION SUPPORT AREA								
Area B Water/Wastewater	196,865	53,845	170	32,683	71,793	355,355	938,517	38%
Utilities & Utilities Area A	212,859	0	9,377	37,201	10,263	269,700	1,247,567	22%
Area B Steam	31,255	1,003	439	57,247	7,031	96,976	701,829	14%
Stores and Receiving	9,569	0	6	1,286	1,929	12,790	148,431	9%
Total Area $	450,549	54,848	9,993	128,417	91,015	734,821	3,036,343	24%
% of Total Area	61.3%	7.5%	1.4%	17.5%	12.4%			
Area % of Total Env $ and Total Activity $						23%	14%	
MAINTENANCE AREA								
Roads & Grounds Maintenance	73,909	1,477	7,172	69,240	11,172	162,970	606,923	27%
Building Maintenance	37,093	0	0	8,740	0	45,833	223,483	21%
Electrical & Instrumental	111,631	0	36,862	3,478	0	151,971	869,398	17%
Area Maintenance & Mechanical	198,944	0	0	89,526	10,253	298,723	2,004,625	15%
Engineering and Project Mgmt.	40,007	13,868	38,136	5,173	12,217	109,400	880,483	12%
Total Area $	461,583	15,344	82,170	176,157	33,642	768,896	4,584,912	17%
% of Total Area	60.0%	2.0%	10.7%	22.9%	4.4%			
Area % of Total Env $ and Total Activity $						24%	21%	
SUPPORT AREA								
Environmental Affairs	17,284	20,317	30,626	208,096	273,110	549,433	558,530	98%
Analytical Labs/Env. Quality	31,399	45,620	15,959	13,593	70,021	176,591	558,460	32%
Security, Fire, Emergency	102,861	0	28,227	23	10,886	141,997	1,004,002	14%
Medical	6,540	0	0	7,160	0	13,700	108,531	13%
Safety	12,339	2,522	3,788	8,646	12,077	39,371	336,220	12%
Development/Quality Assurance	19,090	15,301	291	4,372	874	39,929	746,116	5%
HDC Management Team	10,465	6,424	12,141	11,206	2,975	43,210	837,995	5%
Employee Benefits/Personnel	761	14,186	142	8,752	5,237	29,078	638,849	5%
Purchasing	2,185	1,382	1,866	1,477	635	7,545	285,997	3%
Corporate Business Planning	3,455	0	15	281	295	4,046	177,189	2%
Financial Services & Payroll	6,435	98	98	0	2,590	9,221	470,871	2%
Contracting Services	3,053	1,587	0	0	0	4,639	646,497	1%
Information Systems and Services	0	0	0	0	3,823	3,823	695,066	1%
Total Area $	215,868	107,437	93,152	263,605	382,524	1,062,584	7,064,320	15%
% of Total Area	20.3%	10.1%	8.8%	24.8%	36.0%			
Area % of Total Env $ and Total Activity $						34%	32%	
Other (Health and Taxes)							1,470,213	0%
TOTAL ENV $ & ACTIVITY $	1,537,255	187,124	199,040	699,302	523,256	3,145,977	22,240,304	
% OF TOTAL ENVIRON $	49%	6%	6%	22%	17%	100%		
% OF TOTAL ACTIVITY $	7%	1%	1%	3%	2%	14%	100%	

As also shown in Figure 9, the composition of environmental costs within each functional area at Holston differ generally along "operational" lines. For example, in the Production, Production Support, and Maintenance areas, environmental costs in the Prevention category are 70.6%, 61.3%, and 60.0%, respectively, of the total environmental cost within each area. In the Support area, however, Prevention costs are only 20.3% while Reporting costs are 36.0%. This emphasis on Prevention in the areas that have greater "hands on" activities would be expected while a more administrative function, such as Reporting, would be of greater importance in the Support function.

D. Environmental Cost of Products

The environmental cost by environmental cost objective for each product is shown in the table below. Of the total cost of all activities, $16,324K were incurred directly in production of the eight primary products with the remainder being involved in performance of the sustaining and one-time special contract activities that were not analyzed as to their environmental nature. Of this direct production cost, $2,780K or 17% was incurred due to environmental requirements and consisted of expenditures in the environmental categories shown in the table.

Holston: Figure 10
Environmental Activity Cost Analysis
Environmental Cost of Products
Environmental Cost by Environmental Cost Objective
Six Month Period Ending 06/30/97 ($000)

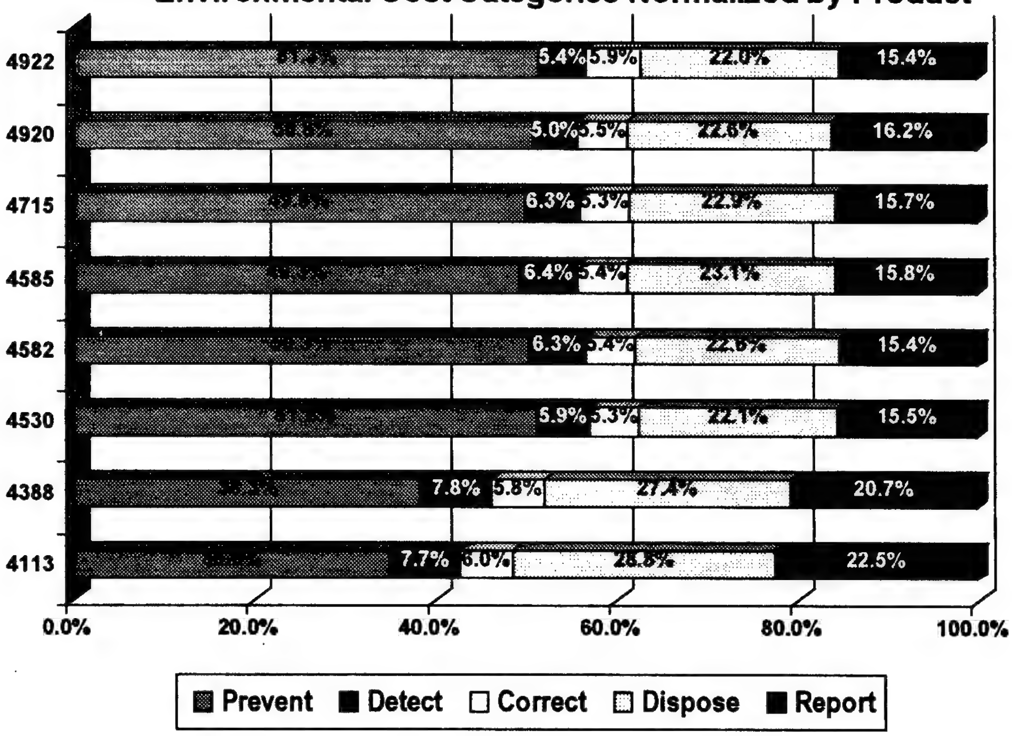
Ref	*Product*	*Product Cost $*	*Job Task $*	*Prevent*	*Detect*	*Correct*	*Dispose*	*Report*	*Green $*	*Green %*
4113	COMP C-4 CL.3 W/TAGN	1,279,708	1,226,567	72,039	15,910	12,314	59,359	46,471	206,093	16.8%
4388	CXM-3 (RDX/DOM)	333,858	317,270	19,911	4,062	3,011	14,215	10,722	51,921	16.4%
4530	OCTOL 75/25 TYPE I	931,223	849,803	73,101	8,484	7,569	31,514	22,117	142,785	16.8%
4582	PBXN-5, TYPE II, CL.3	785,327	712,888	56,603	7,060	6,041	25,439	17,283	112,426	15.8%
4585	PBXN-9	191,132	172,760	14,357	1,868	1,576	6,709	4,591	29,102	16.8%
4715	LX-14-0	224,842	202,717	17,285	2,173	1,852	7,965	5,439	34,714	17.1%
4920	HMX, GRADE B, CL.1	636,474	563,682	52,747	5,172	5,665	23,521	16,778	103,884	18.4%
4922	HMX, GRADE B, 80S	13,772,259	12,279,138	1,077,456	113,279	124,582	461,441	323,143	2,099,901	17.1%
	Grand Total	18,154,822	16,324,824	1,383,499	158,007	162,609	630,165	446,544	2,780,825	17.0%
			100.0%	8.5%	1.0%	1.0%	3.9%	2.7%	17.0%	

E. Environmental Cost of Products by Environmental Category

Figure 11 shows, for each product, the percentage of environmental cost category "normalized" in relation to the total environmental cost for the product. For example, for product 4922, 51.3% of the environmental cost of that product is incurred for prevention activities while 5.4% is for detection, 5.9% for correction, 22.0% for disposal, and 15.4% for reporting.

As shown in Figure 11, for the six products that are HMX-based, approximately one half of all environmental costs incurred are for prevention activities and costs for other types of environmental activities are highly similar among these products. For the two RDX-based products (4388 and 4113), costs are very similar between the two products while prevention activities for both are dramatically lower than for HMX products. These differences in the amounts within the categories of environmental costs between the families of products may be driven in part by their consumption of different quantities of nitric acid and acetic anhydride in their production or by differences in reaction times.

Holston: Figure 11
Environmental Activity Cost Analysis
Environmental Cost Categories Normalized by Product



Regarding the consumption of nitric acid, the RDX family of products consumes relatively less nitric acid than does the HMX family. The quantities of

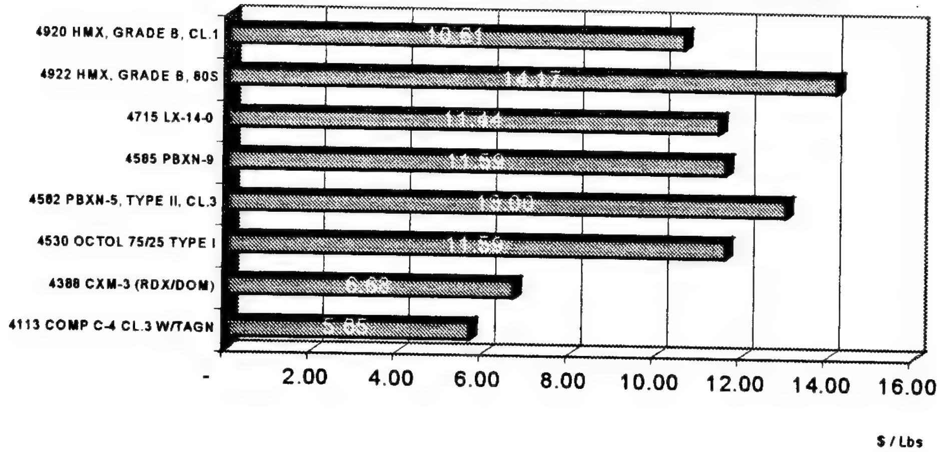
nitric acid required for the RDX family products are 97% and 169% of finished product weight. The nitric acid consumption for HMX based products is significantly larger ranging from a low of 248% to a high of 329% of finished product weight. Differences in the consumption of acetic anhydride in the production of RDX and HMX family products is much more dramatic than in the case of nitric acid consumption. Finished RDX products consume acetic anhydride at rates of 151% and 263% of the finished product weight while HMX products have percentage acetic anhydride use rates ranging from 892% to 1,183% of finished product weight.

Nitration time is another factor that may be associated with differing environmental production costs between the two product families. For RDX products, the nitration reaction time is 35 minutes, while for HMX products the nitration reaction time is 48 minutes. The longer reaction time requires higher usage of steam and river water while producing a higher volume of wastewater. These considerations act to multiply the environmental cost effect associated with the extended nitration reaction time for the HMX products.

F. Environmental Activity Cost per Unit

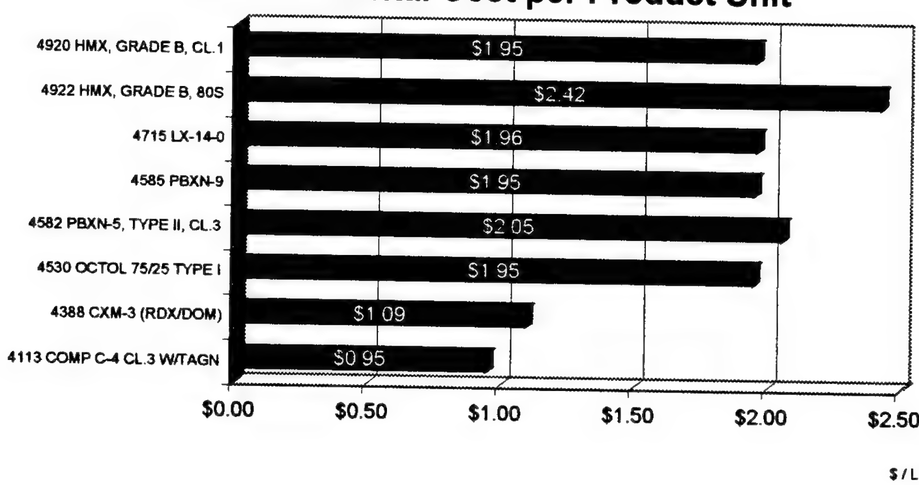
The activity cost of each Holston product is shown in Figure 12. The cost shown for each product is the cost derived from the ABC driven analysis of operations and costs at Holston. Therefore, these costs represent only the costs of actual production and the activities necessary to carry on that production. As previously discussed in this paper, the costs of sustaining activities and certain costs mandated by accounting procedures were excluded from this analysis. In addition, the cost per unit for each product is based on the specific cost relationships and unique cost drivers identified in this study. Assigning resource cost to a product based on unique drivers may produce dramatic differences between that cost and a cost based on an arbitrary cost allocation process. For these reasons, the costs per unit shown below may differ dramatically from the "costs" of these products for contract negotiation or other purposes. These costs are also not affected by variations in levels of total production. Linking costs to products through activity and resource drivers impounds the causal relationships between costs and products. Therefore, although total costs will vary as production volumes vary, per unit activity based total cost and environmental cost will not vary based solely on volume variations.

Holston: Figure 12
Environmental Activity Cost Analysis
Activity Based Unit Product Cost



The environmental cost percentages for each product can be used to quantify environmental costs per unit for each product. These environmental per unit costs are shown in Figure 13. As indicated, the environmental cost per pound of product ranges from a high of $2.42 to a low of $.95. These per unit environmental costs are not affected by variations in volume of activity. These costs are linked to product through activity and resource cost drivers that reflect per unit causal relationships.

Holston: Figure 13
Envinronmental Activity Cost Analysis
Environmental Cost per Product Unit



VII. Inferences from Holston Findings

There are a number of inferences that are possible given the findings concerning the environmental costs of functional areas and of products at Holston. The following discussion of a number of those inferences serves not as explanations or definitive answers but as stimuli for discussion and further examination.

A. Substantial Environmental Prevention Costs

Of the total costs incurred by HDC operations during the six-month period under analysis, approximately 14% or $3,146K of those costs are environmentally driven. Of that environmental cost total, 49% was incurred for expenditures classified as preventive in nature. This substantial percentage of prevention costs may be due in part to the maturity of operations at Holston and in part to the nature of the products being produced. The fact that production processes at Holston involve not only environmental considerations but critical safety considerations also supports an emphasis on preventive activities. If a problem of discharge or escape occurs in the case of products produced at Holston, such a problem is not only a potentially long-term consideration for the environment but also a critical immediate safety concern for the employees of Holston and the inhabitants of the surrounding area.

The production operations at Holston have used the same basic processes for almost half a century. Such stable long-term operations may have resulted in the institutionalization of a concern for prevention of problems before they occur. This situation logically suggests an operating environment in which potential problems have been thoroughly identified and the steps necessary to prevent those problems included as integral, well-developed elements of standard operating procedures. This is in contrast to operating environments marked by short production runs, evolving and changing production processes, and relatively new work force structures. In these latter situations, environmental problems could possibly emerge before they are anticipated. In rapidly changing operating situations, resources may be largely directed toward developing new products and processes with many times little opportunity for anticipation of problems not directly affecting those two concerns. In these environments, the costs for environmental objectives such as detection, disposal, and correction may exceed the expenditures involved in prevention.

B. Significant Environmental Cost in Non-Production Areas

A major finding of this study is the fact that environmental costs incurred in the production support function at Holston was approximately 1.25 times greater than those incurred in the direct production function (23% versus 18%, respectively). The environmental costs of the other two non-production areas, Maintenance and Support, were 24% and 34%, respectively, of total environmental costs. These figures combine to indicate that over 80% of the environmental cost incurred at Holston came from functional areas other than in direct production of products.

In this study the direct production area was differentiated from the production support area based on differences in the degree of direct involvement in production by the work force of each respective area. The production area work force is directly involved in the hands-on manufacture of products. Production support personnel at Holston are engaged in activities that directly support the manufacturing process through such activities as materials handling, steam creation and provision, utilities, and water/wastewater handling. It is in the Production Support functional area where coal is burned, acids are stored and moved, and other environmentally sensitive activities are performed. The Maintenance function carries out maintenance of both production and non-production equipment and facilities. The Support area provides general administrative support for the entire organization.

This finding of significant levels of environmental costs in non-production areas is important in that it lends credibility to the increasing concern regarding the importance of environmental cost "hidden" in overhead functions (i.e., non-production functions). The presence of environmental costs hidden in overhead represents a twofold problem of (1) they are indeed hidden and thereby not included in environmental decision making and (2) they are included in total overhead that is "allocated" to products through arbitrary means involving no causal relationships. As suggested by the EPA (1995 10) environmental costs classified in overhead "can easily be forgotten when managers and analysts focus on operating costs of processes, systems, and facilities." Since non-production area costs are often allocated to products through arbitrary methods, environmental costs incurred in these areas will in turn be arbitrarily allocated to products. If individual products consume differing amounts of the resources in non-production areas, a process of arbitrary allocation may significantly misstate the environmental costs of those products. The standing presumption may be that the environmental costs incurred in non-production areas are insignificant compared to those incurred in direct production, thereby suggesting no need to more accurately address the assignment of those costs to products. The finding at Holston of higher levels of environmental cost as a percentage of total environmental cost in non-production versus production areas challenges this presumption.

C. Differences in Environmental Cost of Product Families

The HMX-based products have slightly higher environmental cost percentages than do the two RDX-based products. This combined with the substantial differences in the categories or types of environmental expenditures between the two product families suggest that environmental costs may be in part formula driven. The RDX family of products uses considerably less nitric acid and substantially less acetic anhydride in production than do HMX based products. Given that acid handling in the production support area generates substantial environmental costs, the differences in usage act as multipliers to accentuate the differences in environmental cost between HMX and RDX based products. In the actual production process, HMX based products consume more steam and river water, and therefore produce more wastewater than do the RDX based products.

These findings suggest that differences in environmental costs may be formula or product composition driven more so than process or operations driven. The RDX and HMX families of products pass through essentially the same production processes and operations. However, due to differences in the times spent in those processes that appear to be formula related, the environmental activities required for each family of product differ significantly.

D. Holston as a Benchmark for Mature Operations

The environmental cost information provided by the analysis of Holston operations may serve as a useful benchmark for organizations with emerging and volatile processes and products. The Holston production operations involve mature products with stable production processes and a highly experienced work force structure. Over a long period of time Holston operations have been refined, reworked, and improved. The current operations and their related environmental cost levels and categories of environmental costs may be a near-optimum configuration that has evolved over a long period of stable production operations. If this is the case, then the Holston data may provide a benchmark for reference. Organizations facing short production runs using varying and highly evolving production processes operated by a work force that is constantly in a new product/process learning mode may reference the Holston environmental cost structure as a benchmark against which to measure their own environmental progress.

VIII. Conclusions and Suggestions for further research

A. Conclusions

Given that there are no similarly established environmental cost benchmarks against which to compare the 14% environmental cost included in the cost of all activities at Holston, no inferences can be made as to whether that figure represents a high, moderate, or low level. However, 14% does appear to be a low to moderate level of environmental cost given that there are apparently no known dramatic environmental problems being created by current operations at Holston even in the presence of the various acids and other chemicals used in operations. The fact that a relatively large percentage of the total Holston environmental cost is incurred in prevention activities may contribute to this overall low to moderate level of environmental cost. The relatively high level of attention given to prevention may be a contributing factor to lowered expenditures on activities involving disposal, detection, and correction by eliminating the need or source of these other activities.

The significant levels of environmental costs incurred by non-production or overhead functions at Holston suggest that environmental activities are not limited solely to the direct production areas. This may indicate a willingness on the part of Holston Defense Corporation's management to ensure that the need for compliance

with environmental requirements is met by a broad-based, organizational-wide effort. This is contrary to the tendency in some organizations that may choose to leave environmental concerns to a specific environmental affairs organizational function. The fact that critically important safety issues many times closely parallel environmental issues may also contribute to the high level of preventive activities at Holston.

The fact that there were dramatic differences in the types of environmental expenditures between the two families of products produced at Holston suggests that formula differences may be a primary driving factor of environmental costs. Given the same basic manufacturing processes and operating facilities, the differences in formula composition of the product families potentially can be directly linked to differences not only in cost per unit of finished product but also the types of environmental cost incurred in its production.

The maturity of the manufacturing processes and the products produced at Holston have allowed time for problems to be anticipated, recognized, and addressed. For this reason, the environmental cost levels in total and the types of environmental expenditures may provide benchmarks for less mature operations. Whether these levels at Holston are indeed the appropriate levels is one issue but, given that there are relatively few if any benchmarks of this kind available, they are useful as points of reference.

Concerning the application of the EACA method at Holston, the process appears to be capable of successfully differentiating between total environmental cost and environmental cost categories of products in a multi-product manufacturing environment. As indicated by results of the EACA analysis cited in prior sections of this report, the process successfully identified unique environmental costs of the various products produced at Holston. The process also successfully differentiated between environmental costs of various operating functional areas at Holston. This latter differentiation is necessary to accentuate the facts that environmental costs are incurred in all functional areas of the organization but the nature of those costs may differ significantly among those functional areas. These considerations are important if management is to develop and tailor an overall organizational approach to address the environmental requirements faced by the firm.

B. Future Research

Both the application of the EACA process at Holston and the findings it produced provide a number of suggestions regarding future research in developing ways in which environmental costs can be identified and quantified at the operating activity level in organizations. The primary suggestion is that the method must now be tested in a multi-product, multi-life cycle setting. The previous SADARM study and the Holston effort have demonstrated the robustness of the method in both single-product/multi-life cycle stage and multi-product/single-life cycle stage settings.

The potential association between types of environmental costs and differences in the formulas of products should be tested by future research. The findings at Holston raise the issue of which may be the more critical contributing factor to environmental cost: the formula or composition of the product or the nature of the manufacturing process used to create that product.

One critical need for future research is analysis of as many operating environments and manufacturing processes as possible in order to establish benchmarks for levels and types of environmental expenditures. This would provide benchmarks necessary for an organization to compare its environmental efforts, as measured by levels and types of environmental costs, with other organizations. An extension of this benchmarking process might be to carry out environmental cost analyses in situations with known high levels of environmental problems and in situations with the same potential for but with little or no actual problems. If two organizations with highly similar products/processes but with dramatically differing effects on the environment (i.e., benign versus detrimental) could both be analyzed, then the levels, organizational function locations, and types of environmental expenditures could be examined for any significant correlations.

References

United States Army PBMA. 1995. *Environmental Life Cycle Cost: Sense and Destroy Armor*, (September).

United States Environmental Protection Agency, Office of Pollution Prevention and Toxics. 1995. *An Introduction to Environmental Accounting As A Business Management Tool: Key Concepts and Terms*. Washington, DC: EPA.

Holston
Environmental Activity Cost Analysis
Appendix A
Acknowledgements

This study was funded by a grant to the Texas Regional Institute for Environmental Studies (TRIES) from the Strategic Environmental Research and Development Program (SERDP) and administered by the US Navy Office of Naval Research (ONR), Washington DC. Through the efforts of ONR personnel, the Holston Defense Corporation, operator of the Holston Army Ammunition Plant, Holston, Tennessee, agreed to cooperate with the TRIES research team in conducting the study.

A number of personnel who contributed to this study in many ways are listed below. This study would not have been possible without their efforts and support. Any omissions of individuals who should have but were not included are the sole responsibility of the Project Manager who expresses his regrets for any oversights.

Texas Regional Institute for Environmental Studies:

Project Manager:

Ross Quarles, PhD, CPA
Associate Professor and Chair, Department of Accounting
College of Business Administration
Sam Houston State University
Huntsville, Texas 77341-2056
Ph: 409-294-1258
aac_nrq@shsu.edu

Activity Based Costing Consultant:

Alan Stratton, MS, CPA, CMA
Dynamic Management Associates
14335 SW 161st Ave.
Tigard, Oregon 97224
Ph: 503-590-3911

Team Members:

Ennis Hawkins, Professor of Accounting, Sam Houston State University
Keith Hunziker, Research Fellow, TRIES
Glenn Peters, Environmental Consultant, Houston, Texas
Mark Tuttle, Research Assistant, TRIES
Mike Warnock, Executive Director, TRIES

ONR Technical Point of Contact:

Jim Short, PhD
Office of Naval Research
Washington, DC

Holston Defense Corporation:

This study would not have been possible without the support and full cooperation of the management and employees of the Holston Defense Corporation. These individuals created a work environment and exhibited a spirit of cooperation with the research team that is rarely found in projects of this type. Although the individuals identified below provided special assistance in a number of ways, the project owes a critical debt to the 114 individuals who directly participated in the storyboarding sessions held at Holston. These storyboarding participants provided not only a vast wealth of experience and knowledge but openly, cheerfully, and fully shared that experience in sometimes lengthy work sessions.

President, HDC and Plant Manager:

A. L. King

Project Coordinator:

Charlie Brumley

Senior Accountant:

Don Neff

Holston
Environmental Activity Cost Analysis
Appendix B
The Method of Analysis Developed and Used for Identifying and Quantifying Environmental Activity Cost

Abstract

In order to make informed decisions regarding environmental issues, two factors must be quantified: benefits and costs. The measurement of environmental benefits is many times problematic given the varied definitions of benefits arising from economic, political, social, and scientific perspectives. Regarding environmental costs, many of these same definitional difficulties are present concerning the issue of public or external costs. In regard to private or internal environmental cost of manufacturing, however, there is an unstated assumption that existing, traditional accounting information systems can provide an accurate measurement of environmental costs directly incurred by an organization in carrying out its functions. This assumption is, unfortunately, incorrect. Traditional accounting information systems, as they are currently configured, do not adequately identify, quantify, or report environmental costs incurred in operations. This study describes a system developed under this research project that provides a method through which the problems of traditional accounting cost analysis can be overcome and internal environmental costs of manufacturing identified, quantified, classified, and reported for decision making. This method, Environmental Activity Cost Analysis (EACA), uses the basic framework of Activity Based Costing and incorporates a new data-gathering technique developed during this project, Environmental Activity Storyboarding.

1. Introduction

In addressing the issue of integrating economics with environmental protection, two critical factors must be identified: costs and benefits. While the identification and quantification of environmental benefits is a complex issue involving scientific, political, social, and other considerations that are beyond the scope of this discussion, the identification and quantification of environmental costs also is a complex issue in its own right. Environmental costs consist of external or societal costs and internal or private costs. As defined by the EPA (1995 16), external environmental costs are the costs borne by society as a whole and for which business is not legally accountable (e.g., environmental degradation for which firms are not legally liable or adverse impacts that cannot be compensated through the legal system). Since external costs are societal in nature, their identification and measurement are affected by many of the same political, scientific, and social considerations that affect measurement of environmental benefits. Internal or private environmental costs, as defined by the EPA (1995 16), are costs incurred by a particular entity and, in the case of a business, directly affect the firm's bottom line profits. However, even though private costs are less difficult to measure than

are external costs, that task is not as easily accomplished as might be thought. Existing, traditional cost accounting information systems generally cannot and do not identify or directly measure the full private costs incurred by an entity in addressing environmental issues. In most cases if a business were required to determine its environmental cost for a period, the accountants would simply sum the total of items such as amounts paid to disposal contractors, amounts paid for construction of end-of-pipe disposal equipment and facilities, salaries and benefits paid to manage the firm's environmental program, legal fees paid for permits, and amounts paid for environmental consultants. While this total amount would undoubtedly be quantitatively accurate, it very well could be woefully inadequate in identifying the total environmentally-driven private costs incurred by the company. Traditional accounting information systems geared for external reporting and for managerial decision making do not specifically identify costs as environmental and generally do not adequately measure the cost of environmental activities carried out by general overhead and administrative functions (Hamner and Stinson 1995; Ditz et al 1995). Although these costs do become a part of the final cost of the products produced by the organization, they frequently do so through arbitrary overhead cost allocations that do not reflect any cause and effect relationship between costs and product or services.

One might argue that since private environmental costs do eventually become a part of the cost of products or services provided by a firm even if they are not explicitly identified as environmental, then why should identification and quantification of environmental costs as such be so critical? The answer is threefold. First, many benefits accrue when environmental costs are explicitly identified and quantified. In its work with key stakeholders, the EPA (1993) has concluded that as businesses more fully account for environmental costs and benefits, those businesses will clearly see the financial advantages of pollution prevention practices. Practices such as product design changes, input materials substitutions, process re-design, and reduction of waste generation below compliance reporting thresholds can all act to reduce environmental costs and increase profits. A study cited by the EPA (1995) supports this position, reporting that organic chemical plants with some type of environmental cost accounting program had three times as many P2 projects as did plants with no such programs. Second, the study indicated that in production facilities for which data were available, each dollar spent annually on pollution prevention resulted in annual savings of $3.49 in other costs. Third, the old axiom that "one cannot manage that which one cannot see" is pertinent to this issue. If environmental costs are not identified and measured, then environmental costs (and the activities and effects they represent) will not be managed. As the EPA indicates, identifying environmental costs and separating them from overhead accounts where they are often hidden reveals these costs to managers and others who are responsible for controlling them. The EPA suggests that understanding and accounting for environmental costs as part of environmental accounting can

> (1) support a company's overall environmental management system,
>
> (2) lead to more accurate product costing and pricing,
>
> (3) foster more environmentally preferable designs, and
>
> (4) result in reduction of environmental costs that may provide no added value to products, services, or processes. (EPA 1995)

In order to overcome the inadequacy of existing accounting systems in identifying and quantifying private environmental costs and to obtain the potential benefits that may accrue due to that outcome, a new method of accounting analysis must be developed. The EPA has suggested a broad approach described as life-cycle cost assessment, defined as a "systematic process for evaluating the life-cycle costs of a product, product line, process, or facility by identifying environmental consequences and assigning monetary value to those consequences" (1995 32). In other words, the cost information provided through life-cycle cost assessment should be of use to the individuals who must make decisions regarding the activities carried out within each stage of the life cycle. However, in developing the concept of life-cycle cost assessment, exactly what methods should be used to identify environmental consequences and assign monetary value have yet to be identified by the EPA. In this regard, the sections of this paper that follow describe a method of environmental cost analysis that was developed and applied in this research project.

The environmental cost analysis method developed in this research project was applied to a single phase in the overall life cycle of selected sample products. The results of this application indicated the feasibility and effectiveness of the analysis method in accomplishing the identification and quantification of environmental costs. The scope of each of these research projects was limited primarily to a single stage of the life cycle (i.e., the manufacturing stage). However, the analysis method can be applied to each stage of a product's life cycle defined by the EPA (1993) (raw material acquisition, manufacturing, use/reuse, and recycle/waste management) to determine overall life cycle environmental costs.[1] This process is consistent with the EPA's characterization (1995) of environmental cost accounting.

2. Environmental Cost Accounting

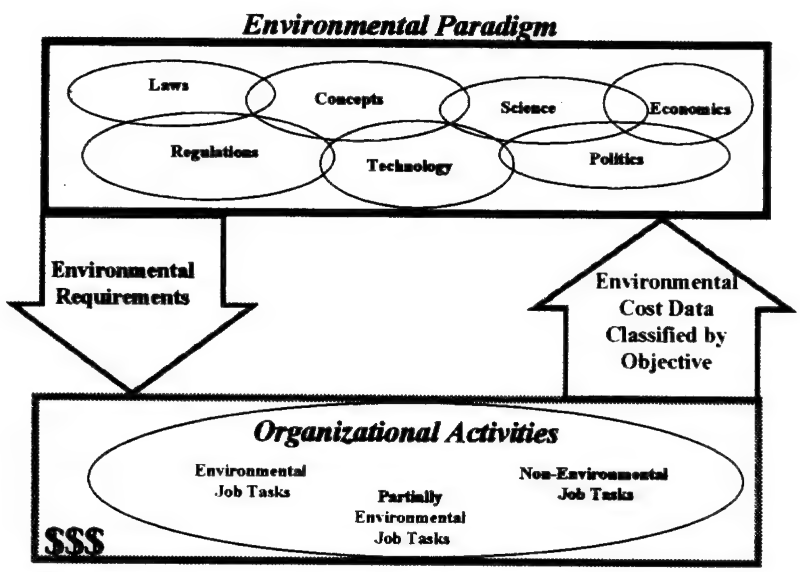
As defined by the EPA, environmental cost accounting is "the addition of environmental cost information into existing cost accounting procedures and/or recognizing embedded environmental costs and allocating them to appropriate products or processes." (1995 30) Under this definition, in order to accomplish or "do" environmental cost accounting, two problems must be solved: (1) how to identify and quantify embedded environmental costs and (2) how to accurately assign those costs to products or processes. Traditional methods of analyzing accounting and operating information do not satisfactorily address these problems. Some method is necessary to permit identification of the environmental costs hidden within the operations of an organization. Any method developed to accomplish this identification must be applied to all operations of an organization in order to identify all environmental costs, regardless of the location in the organization where they may occur.

For purposes of analysis, an environmental cost can be defined as any cost that an organization incurs in performing an environmentally driven task. Why a particular job

[1] Given that the scope of the research was limited primarily to manufacturing, it was assumed that the cost of materials used in manufacturing included all environmental costs incurred in the raw materials acquisition even though those costs were not separately identified in the purchase price paid.

task can be described as environmentally driven is due to the particular set of environmental requirements that affect the organization or the specific task at a point in time. Environmental requirements represent factors that shape and form what is of importance in regard to the environment. These environmental requirements could be laws, regulations, customs, state of the art technology, or what society, economics, or politics demand of an entity regarding the environment. The combined effect of these factors forms the environmental paradigm that shapes what an organization both must do and cannot do regarding tasks and activities that impact the environment. For example, at any given time an entity is subject to a number of environmental regulations imposed by federal, state, and local governmental bodies. If a particular task is required in order to meet those regulations, then that task is environmentally driven. Should a particular task be required as a replacement for a prohibited task, then that replacement task is environmentally driven. Figure 1 demonstrates how the various factors combine to create the set of environmental requirements that affect an organization at a given point in time. The figure also suggests that an organization must carry out environmental tasks, partially-environmental tasks, and non-environmental tasks in accomplishing its activities. In order to determine the environmental costs included in those activities, some method must be used to distinguish non-environmental tasks and their costs from environmental and partially-environmental tasks and their related costs.

Figure 1:
The Effects of the Environmental Paradigm on Organizations



Environmental Activity Cost Analysis Process

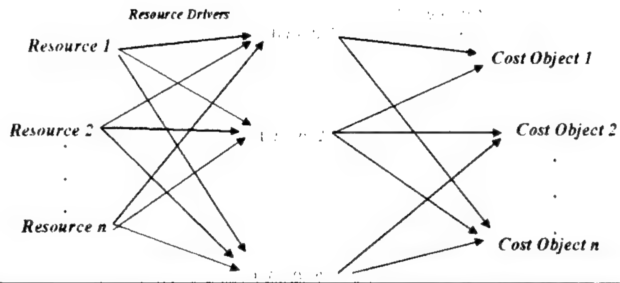
3. Attributes of a Method for Identifying and Quantifying Environmental Costs

The relationships between tasks and activities, between activities and resources (and resource costs), and between activities and cost objects can be used to provide a solution to the problem of how to identify and quantify environmental costs. The method developed to do this must include a detailed analysis of organizational operations in order to identify those tasks that are performed due to environmental requirements. Any task necessary for production of a product or operation of a process may be performed (1) exclusively due to environmental requirements, (2) partially due to environmental requirements, or (3) in no manner due to environmental requirements. For example, in a manufacturing area using a paint booth, maintaining necessary records and completing a required environmental report is accomplished solely and completely due to environmental requirements. Disposal of a batch of hazardous waste produced in manufacturing is done in part because such disposal is necessary for ordinary operations but also in part due to environmental requirements for proper disposal. Scheduling production workers to operate various pieces of equipment may be a necessary task for operations but is generally not affected by environmental requirements. The objective, therefore, is to identify those individual job tasks that compose a given activity, identify which are driven in total or in part by environmental requirements, and determine the quantity of resources consumed by those environmentally driven tasks. The quantities (and costs) of all environmental job tasks within a given activity can be summed to produce the total environmental cost for that activity.

Any method of analysis designed to support environmental cost accounting must have the capacity to address environmental costs that are included within overhead functions of an organization. Some activities performed by overhead functions are affected either totally or in part by environmental requirements. Those environmental activities must be identified and their costs assigned to the products or processes they support, based on an accurate process of cost assignment. Unless costs of environmental activities performed by overhead functions are determined and assigned accurately to products and processes, any quantification of environmental cost of a product or process is in danger of being grossly inaccurate. This inaccuracy looms as an increasingly critical issue given the growing proportion of overhead costs included in product and process costs due to factors such as increasing use of technology and automation.(White et al 1995)

To support environmental cost accounting, a cost analysis method must identify the smallest manageable unit for which cost can be identified and analyzed. Under the framework of Activity Based Costing (ABC), that unit of measure is the individual activity that is carried out in support of production or operations. However, as indicated in Figure 2, some of the individual tasks that make up a given activity may be totally or partially environmental while other tasks in the same activity are completely non-environmental in nature. Therefore, any method for analysis of environmental costs would necessarily involve determining the proportion of each job task that may be environmentally driven in relation to resources consumed, activities performed, and cost objects benefited.

Figure 2:
Flow of Costs in the ABC Framework



4. Activity Based Costing as the Basis for Environmental Cost Analysis

Activity Based Costing (ABC) provides the conceptual framework for the environmental cost analysis method developed in this project. As described by Robinson, ABC identifies the true cost of products and services, measures the cost of resources consumed, and "generates a new source of information previously beyond the reach of managers facing resource allocation challenges" (1997 52). As a method, ABC measures the cost of process-related activities and assigns resource costs to the activities that use the resources on the basis of that usage. The method then assigns cost activities to cost objects (products, customers, etc.) that use those activities based on their usage of each activity (Cokins et al 1993). In other words, under the ABC view, resources are consumed by activities and activities are used to serve cost objects. Figure 2 describes this process graphically. By identifying the cause and effect consumption relationships between resources and activities (resource drivers) and the cause and effect usage relationships between activities and cost objects (activity drivers), an accurate cost of the resources consumed can be tied to cost objects produced. This cause-and-effect quantification is superior to the arbitrary cost allocation schemes of traditional accounting.

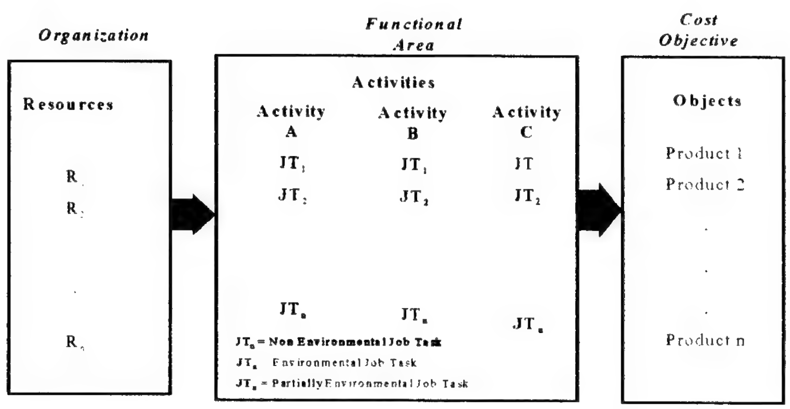
The general ABC cost analysis process can be focused to examine unique classifications of drivers and cost relationships that are caused by specific requirements such as environmental, safety, regulatory, or other issues. In the current study, the ABC process was used to focus on the environmental costs incurred in the manufacture of energetics due to requirements generated by the combined elements of the environmental paradigm. The method developed in this study to apply ABC to these environmental cost issues is defined as Environmental Activity Cost Analysis (EACA).

5. Environmental Activity Cost Analysis (EACA)

A process of Environmental Activity Cost Analysis (EACA), based on the ABC framework, was developed for use in this project. This process is essentially identical to the ABC analysis process but with an added dimension to address environmental costs. An examination of Figure 2 suggests why the ABC framework can be adapted to identify

and quantify environmental costs that flow through a given organizational function. Individual job tasks represent the smallest identifiable things that must be done in order to carry on the work of the function. Any one of these individual tasks may be performed due to environmental considerations. For example, if job task 2 within Activity A is identified as being an environmental job task (to be defined in a subsequent section) then part of the resource cost flowing through Activity A to the cost objects that consume that activity can be defined as environmental. If all environmental job tasks in the organizational function are identified, then the total environmental cost of each cost object can be quantified. By recognizing that some job tasks may be performed in order to meet environmental requirements, an analysis process was developed to quantify the environmental cost included in the total cost of each cost object. Figure 3 graphically displays how the EACA process is conceptually described.

Figure 3:
Flow of Costs in the EACA Process



In Figure 3 the environmentally driven job tasks that are performed within each activity in the function are identified. By identifying the costs of resources that flow into those environmental job tasks and then linking those job tasks with the cost objectives which they benefit, the environmental cost included in the total cost of each cost objective can be determined. This determination will provide the basis for environmental cost accounting.

The EACA process is the result of extensions and improvements made to a bottoms-up or job task driven environmental cost analysis process initially developed in a project sponsored by the US Army (1994) to address the internal environmental cost over the life cycle of a proposed weapon system. This EACA process utilizes an interactive modified Delphi-like group participation process developed as part of this research project and defined as Environmental Activity Storyboarding. The storyboarding process utilizes a focus group or panel who are experts on the functional area under examination. These experts are those individuals (or a representative sample) who work in the area and actually perform the tasks carried out in that organizational function.

The complete EACA process consists of a number of steps designed to obtain data concerning the various elements that are used to develop a model of environmental costs of organizational units and individual products. These steps include:

1. identification of organizational resources consumed by the organizational unit under examination,
2. identification of job tasks and activities performed that consume organizational resources,
3. identification and quantification of resource drivers that measure resource consumption by job tasks,
4. identification of cost objects served by activities and activity drivers that measure activity consumption
5. identification of environmental job tasks,
6. classification of environmental job tasks by environmental objective,
7. calculation of resource consumption by job task based on resource drivers,
8. calculation of organizational unit environmental cost in total and by environmental classification,
9. calculation, for multiple product or service organizational units, of environmental cost by product/service using activity drivers,
10. calculation, for multiple product or service organizational units, of environmental cost of each product/service by environmental classification.

These steps are completed for each functional area in the organization. When the steps are completed for all functions, then the activity driven cost of each cost object served by the total organization is determined by summing the individual unit data.

Step 1:

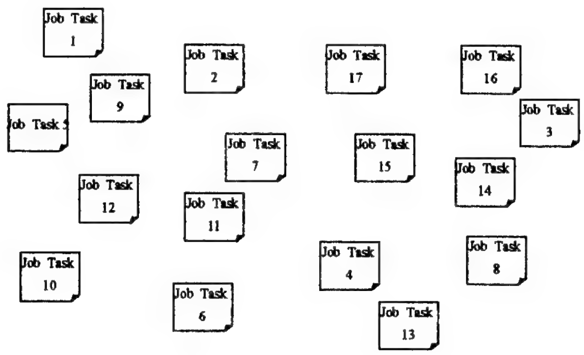
Identification of organizational resources consumed is accomplished through examination of the general ledger or cost system of the organization. For each organizational unit, costs of resources consumed are identified (e.g., labor, equipment, supplies, utilities, facilities, etc.) in order to (1) quantify costs of that unit's operations and (2) suggest types of resource drivers that may be operative for that unit. As a practical point, many times general ledger information contains cost allocations that must be removed prior to utilization for this analysis process. This step ensures that the results of EACA process cost assignments will reconcile to published financial results of the organization.

Step 2:

Identification of Job Tasks and Activities performed in the organizational unit is accomplished through the Environmental Activity Storyboarding process. Individuals who

work in the unit, the experts, identify all job tasks involved in completing the duties and bearing the responsibilities of the function. Figure 4 graphically demonstrates the results of this step.

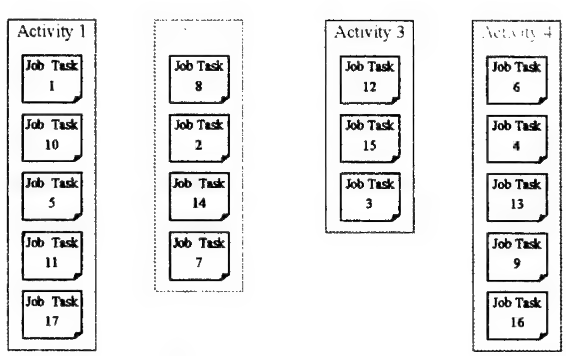
Figure 4:
Identification of Job Tasks



As an example of the level of expertise "captured" by this process, in the Holston Utilities Area B Steam Production function, the five expert participants in the Environmental Activity Storyboarding session had a combined total of 121 years experience working in the function. This represents an average experience level of 24.2 years per expert. Experience levels of experts participating in all sessions at Holston are listed in tables in Appendix C. There were 114 experts that participated in the Holston Environmental Activity Storyboarding sessions with a combined experience of 2,561 years.

These experts then group the tasks based on similarity of nature of the tasks and name those groupings based on what activities they represent. These groupings of similar job tasks are the activities of the function. Figure 5 graphically demonstrates results of this step in the EACA process.

Figure 5:
Grouping of Job Tasks in to Activities



Step 3:

The experts then identify and quantify the Resource Drivers that measure resource consumption by each job task identified. This quantification indicates the degree of usage of resources consumed in performing the job tasks and activities the experts have identified. In most cases, each job task will involve some degree of labor consumption but may or may not include consumption of other resources such as equipment, travel, supplies, etc. Figures 6a and 6b show results of these steps for two typical resources, labor and equipment, in a given organizational functional area such as a specific manufacturing line operation. These figures exhibit how job tasks are arranged within each activity and the percentage of labor used and equipment used within the functional area under examination. As indicated by Figure 6a labor is used in each task. Figure 6b indicates that not all job tasks require the use of equipment.

Figure 6a:
Quantification of the Consumption of Labor

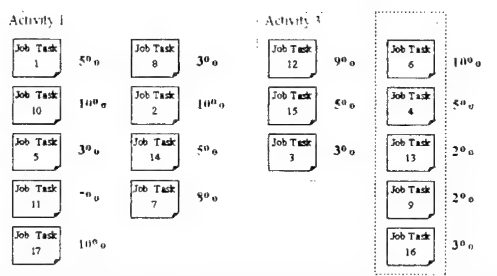
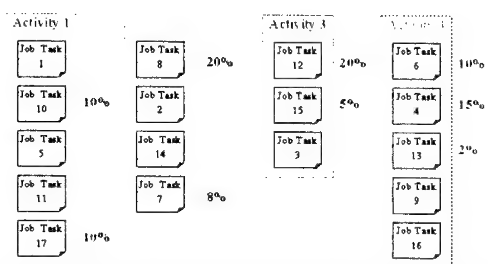
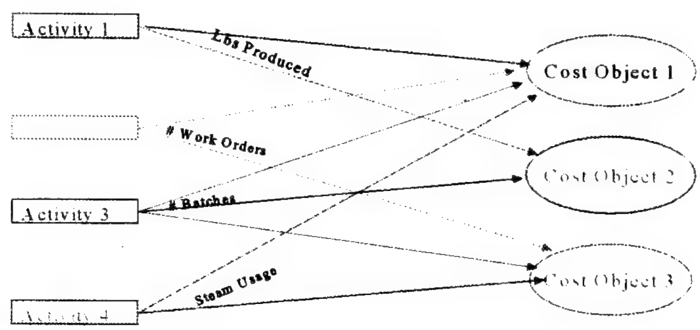


Figure 6.b:
Quantification of the Consumption of Equipment



The next step in the EACA process involves identification of the cost objects served by Activities and identification of the Activity Drivers that measure activity consumption. Cost objects represent the "customers" or products that receive value or have value added due to the function's activities. Activity drivers are measures of demand placed on each activity by the cost objects that it serves and represent the causal links between cost objects and activities. Identification of these causal linkages permits an accurate assignment of the cost of each activity. This assignment is superior to allocations based on arbitrary factors such as volume or direct labor hours. Figure 7 graphically demonstrates linkages of activities and cost objects based on representative activity drivers identified at Holston.

Figure 7:
Cost Objects and Activity Drivers



Step 5:

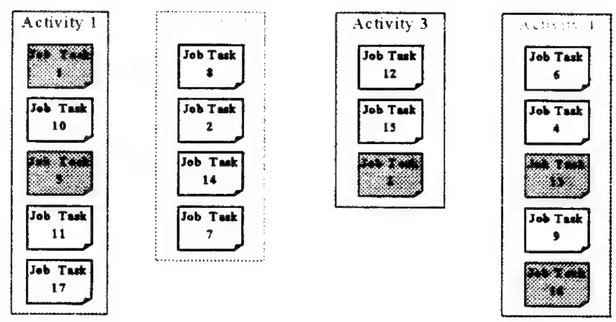
In this step of the EACA process, functional area experts examine each job task. This examination addresses the question of whether there are environmental requirements associated with performance of that task. An independent environmental requirements expert observes this process.

Field application of this process indicates that in the majority of cases individuals who perform job tasks are well aware of environmental considerations that affect their tasks. They know that a specific task is related to an environmental consideration or requirement even if they cannot specify the exact law or regulation involved. Experience in the field with this process indicates that, for example, product design engineers know that many of their tasks performed in the activity of searching for environmentally acceptable alternative materials are driven by environmental considerations or requirements. Production workers who handle specific hazardous wastes may not be aware of the particular law or regulation creating environmental requirements for those wastes, but they are usually quite knowledgeable as to the fact that they have to perform special or modified job tasks when dealing with them. These production workers are also well aware that different types of wastes require different job tasks on their part, even though they may not know the technical or legal reasons for those differences. Shipping personnel are aware that many of their job tasks are affected by environmental requirements related to handling and transportation of hazardous materials.

The basic assumption in this process is that individuals who carry out activities in the function know better than others what they actually do (i.e., the job tasks they perform). The process also relies on the individuals performing job tasks having a high level of knowledge as to which of their tasks are affected by an environmental requirement. However, in order to validate this latter assumption, the entire storyboarding process is observed by an independent environmental requirements expert who can offer suggestions or ask questions to clarify specific issues. In addition, for the EACA process, a job task can be classified as environmental even if no specific law or regulation can be cited that applies to that task. This is in keeping with the EPA position that costs can be considered as environmental costs even if they are not explicitly driven by regulations (1995 11).

Figure 8 indicates results of this process of identification of environmentally driven job tasks.[2] Five tasks (shown as shaded figures) included within three separate activities are indicated as being environmentally driven. Activity 2, however, does not include any tasks that are environmentally driven.

Figure 8:
Identification of Environmental Job Tasks



Step 6:

As the final step in the Environmental Activity Storyboarding process, the experts categorize environmental job tasks and quantify the level of environmental effort involved in each. This step uses a five-category environmental task classification based on the environmental objective of the task. This classification scheme is based on the concepts of Activity Based Costing and the general environmental cost classification framework developed by the EPA (Quarles 1995). The five categories and a brief definition of each are shown in Table 1.

Table 1:
Activity Based Environmental Task Classifications

Prevention	Disposal	Detection	Correction	Reporting
Tasks performed to prevent or deter adverse environmental conditions, events, or consequences.	Tasks performed to dispose of materials or products in an environmentally benign or proper manner.	Tasks performed to determine if an environmentally adverse condition or event has occurred or is occurring.	Tasks performed to remedy or mitigate the existence or effects of an environmentally adverse condition or event.	Tasks performed to comply with regulatory reporting and record keeping requirements.

[2] For the sake of simplicity in this example, it is assumed that a given job task is either environmentally driven in total or not at all. If the experts indicated that a task is in part environmental and in part non-environmental, then they would be asked to indicate the environmental percentage of the task. Only that portion of the task that was considered to be environmentally driven would be included in the subsequent calculations used to determine environmental cost of the particular activity assigned to cost objects.

Step 7:

After completion of the preceding steps, a model emerges that accurately links resources to activities performed and which can be used to quantify resources consumed by each job task in the function. For example, the Holston Utilities Area B Steam Generation function consumes a number of organizational resources (utilities, labor, supplies, maintenance services, etc.) in performing sixty four job tasks that comprise six operating activities. The resource drivers for this function are people time and maintenance effort. The demand placed on the organizational resources by this function varies directly with the number of hours worked by employees and the maintenance effort required to support the unit. Table 2 demonstrates the quantified relationships involving resources, job tasks, and activities in this function based on data obtained for the function. The total organizational resources consumed by the Holston Utilities Area B Steam Generation function amount to $702,000 for the six-month period under examination. These resources consisted of $356,000 for labor or people costs, $175,000 for maintenance, and $171,000 for other costs (e.g., utilities, supplies, subcontractor services, etc.). For the job task defined as "blow soot" in the Dispose of Waste activity, 2% or $8,000 in people costs were consumed, 10% or $17,000 in maintenance costs were consumed, and 3% or $5,000 of other costs consumed for a job-task total of $30,000. The total cost of all job tasks within the Dispose of Waste activity is $97,000 of the total $702,000 total resource consumption by the Area B Steam Generation function.

Table 2:
Resource Consumption by Job Tasks and Activity
Holston Utilities Area B Steam Generation Function ($ 000)

Resources $ 000's	People %	People $ 000's	Maintenance %	Maintenance $ 000's	Others %	Others $ 000's	Activity / Job Task	Task $	Activity $ 000's
							Dispose of Waste		97
	2%	8	10%	17	3%	5	Blow soot	30	
People	1%	2			1%	2	Pump water out	4	
356	3%	12	10%	17	4%	6	Run fly ash equipment	35	
	1%	5			1%	2	Measure flyash	7	
	1%	5			1%	2	Load out cinders	7	
	3%	10			2%	4	Load out fly ash	14	
Maintenance 175							Make Steam		274
	39%	138	40%	70	39%	66	22 various tasks	274	
							Treat Water		49
Others	8%	27	5%	9	8%	13	7 various tasks	49	
171							Receive Coal		148
	21%	76	20%	35	22%	37	9 various tasks	148	
							Make Air		63
	9%	31	10%	17	9%	15	4 various tasks	63	
							Manage Operations		70
	12%	42	5%	9	11%	19	13 various tasks	70	
702		356		174		171	*Total*		702

Step 8:

This step involves calculation of total environmental cost (1) for the total organizational unit and (2) for each category or classification of environmental cost. Total resource consumption by each job task identified as environmental in nature is used to determine total environmental cost for the organizational function. Data concerning the characterization of each environmental job task as to the task's environmental objective are used to calculate environmental cost by environmental classification category. Table 3 shows results of these calculations for the Holston Utilities Area B Steam Generation function. As indicated in that table, total environmental cost for this function is $97,000 or 13.8% of total organizational cost during the period under examination. Total environmental cost of each of the six activities carried on in the function range from a high of $68,000 in the Dispose of Waste activity to $0 in the Manage Operations activity. The environmental cost for individual job tasks in the Dispose of Waste activity range from $35,000 to $1,000.

Table 3:
Environmental Cost of Activities Classified by Environmental Objective

Activity / Job Task	Task $000's	Activity $000's	Preventing %	Preventing $000's	Detecting %	Detecting $000's	Correcting %	Correcting $000's	Disposing %	Disposing $000's	Reporting %	Reporting $000's	Green %	Green Task$	Green Activity$
Dispose of Waste		97		5						56		7	70%		68
Blow soot	30		5										5%	1	
Pump water out	4		100										100%	4	
Run fly ash equipment	35								100				100%	35	
Measure flyash	7										100		100%	7	
Load out cinders	7								100				100%	7	
Load out fly ash	14								100				100%	14	
Make Steam		274		23		1		1					9%		25
22 various tasks	274		8		0		0		0				9%	25	
Treat Water		49								1			2%		1
7 various tasks	49								1				2%	1	
Receive Coal		148		3									2%		3
9 various tasks	148		2										2%	3	
Make Air		63													
4 various tasks	63														
Manage Operations		70													
13 various tasks	70														
Total		702		31		1		1		57		7	14%	97	97

Step 9:

For organizational units that provide multiple products or services, the total environmental cost must be assigned to individual product/service cost objects. Activity drivers form the basis for this assignment. Activity drivers measure demand placed by causal factors by each product or service on the activities of the organizational unit. For example, the Holston Utilities Area B Steam Generation function has three customers or cost objects: Explosives Manufacturing, Explosives Finishing, and Inorganic Acids

functions. The activities of Area B Steam Generation vary directly with the total amount of steam usage by each of these customers. Table 4 indicates how the total activity cost and the green (environmental) cost of each of those activities are assigned to the three cost objects based on quantity of pounds of steam used by each in proportion to total usage.

Table 4:
Environmental Cost of Activities Assigned to Cost Objects

Activity	Activity $000s	Green $000s	Cost Object	Steam Usage		Contribution $000s	Green $000s
Dispose of Waste	97	68	Explosive Manufacturing	189,811	lbs	314	43
Make Steam	274	25	Explosive Finishing	44,524	lbs	74	10
Treat Water	49	1	Inorganic Acids	189,280	lbs	314	43
Receive Coal	148	3					
Make Air	63	0					
Manage Operations	70	0					
Total	$ 702	$ 97	Total Driver	423,615	lbs	$ 702	$ 97

Step 10:

For organizational units that produce multiple products/services, the environmental cost assigned to each cost object must be assigned to classifications based on environmental objectives. The quantity of environmental cost assigned to each classification is the product of the environmental cost classifications provided by the experts and the total environmental cost assigned to each cost object based on activity drivers. Table 5 demonstrates this calculation for the Holston Utilities Area B Steam Generation function. As indicated in that table, of the $68,000 environmental cost incurred in the Dispose of Waste activity, $43,000 is assigned to the Explosives Manufacturing function. Of that $43,000 environmental cost, $14,000 is for Prevention, $26,000 is for Disposal, and $3,000 is for Reporting. Of the $10,000 in environmental costs for the activity of Making Steam, $3,000 is for Prevention, $6,000 is for Disposal, and $1,000 is for Reporting.

Table 5:
Classification of Environmental Cost Assigned to Cost Objects

Activity / Category	Green $ 000's	Allocation	Steam Usage	Steam %
Dispose of Waste			189,811 lbs	45%
Preventing	5			
Disposing	56	56 x 45% = $25		
Reporting	7	56 x 11% = $6		
Total Green	68	56 x 45% = $25		
Make Steam				
Preventing	23	23 x 45% = $10	44,524 lbs	11%
Detecting	1	23 x 11% = $2		
Correcting	1	23 x 45% = $10		
Total Green	25			
Treat Water				
Disposing	1			
Total Green	1		189,280 lbs	45%
Receive Coal				
Preventing	3			
Total Green	3			
Grand Total	$ 97		423,615 lbs	100%

Green $ 000's	Cost Object/ Category
	Explosive Manufacturing
14	Preventing
0	Detecting
0	Correcting
26	Disposing
3	Reporting
	Explosive Finishing
3	Preventing
0	Detecting
0	Correcting
6	Disposing
1	Reporting
	Inorganic Acids
14	Preventing
0	Detecting
0	Correcting
25	Disposing
3	Reporting
$ 97	Grand Total

6. Extending the EACA Process

The Environmental Activity Storyboarding process was repeated for all functional areas of the Holston organization in order to determine environmental costs for the total organization and for each cost object (e.g., product) produced or served. The scope of this research limited application of the EACA method to the manufacturing phase of the life cycle. However, the overall EACA process can, if desired, be repeated for each organization that participates in the life cycle of a product or process to determine overall total private environmental cost associated with creating products or providing services.

In operating or manufacturing functions, the linkages between resources, activities, and job tasks are generally understood if not specifically identified. However, for overhead functions, the identification of job tasks, resources consumed, cost objects, resource drivers, and activity drivers is a new endeavor. The EACA method was applied to all functional areas of the Holston Defense Corporation in order to ensure that all operations and costs were included in the analysis process. The EACA method proved particularly useful in analyzing overhead functions to identify and quantify environmentally-driven costs thereby associating those costs with particular cost objects.

Because Holston is a GOCO (government owned, contractor operated) function, charges for use of equipment and facilities were not included in the analysis (i.e., no costs associated with depreciation). However, all costs associated with maintenance and actual operating costs of equipment and facilities were included in the analysis. The EACA method can readily address depreciation or facilities use costs if those costs are included in the cost of products or services.

In the case of Holston operations, there is a relatively small degree of product differentiation among the various products produced. The EACA process identifies the activity drivers that highlight usage of activities (and resources those activities consume) and which serve as the basis for product differentiation. Since the various products produced at Holston are highly similar in the degree of use of those activities as measured by the activity drivers, there is a small degree of product differentiation. In cases where products differed widely in their relative consumption of activities, product cost differentiation would be much more significant.

7. Uses of Environmental Cost Information

Identification and quantification of private environmental costs consumed in the activities of an organization can be useful in addressing environmental management control and operations issues. Classification of environmental costs by category (prevention, detection, disposal, etc.) allows management to understand the purposes for which environmental expenditures are taking place. For example, if a firm is incurring high environmental costs for disposal and very little for prevention, managers may examine the possibility of a trade off in expenditures between these two objectives. Increased expenditures in prevention may lead to greater savings in disposal expenditures and thereby produce an overall cost saving for the firm.

Identification and quantification of private environmental costs consumed in producing specific products or services can be used for addressing pricing or cost justification issues. Environmentally sensitive customers, consumers or governmental agencies may be willing to allow price or cost increases if those changes can be shown to be driven by environmentally driven activities. This identification of environmental costs may also benefit the process of product selection. For example, two products may have identical sales prices and identical total costs per unit but one has significantly higher environmental cost included in its cost. From the perspective of society as a whole, the product with the lower environmental cost should be produced. Both products would produce the same return to the producing firm but the one with the lower environmental cost component would produce less stress on the environment.

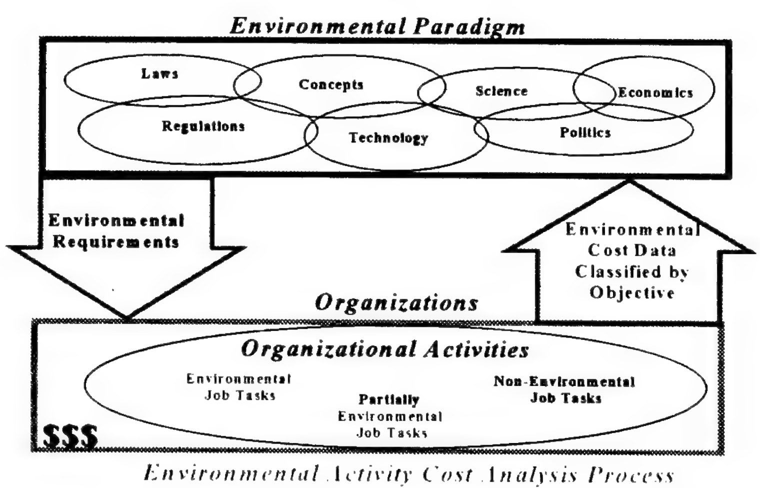
8. Conclusion

EACA provides a method for identification and quantification of costs associated with specific environmentally driven tasks and activities accomplished within an organization or organizational unit. It provides bottoms-up cost data based on information from individuals and functions directly involved in performing environmentally related tasks (i.e., expert data). Individual functional area data obtained in the process can provide a growing database to develop benchmarks for individual functions in similar organizations. EACA provides building blocks of environmental cost information by function that can then be accumulated to produce overall product or process environmental cost and overall organizational environmental cost. It can be used to identify individual product or process cost for each phase of life cycle and across life cycle phases to yield

total life cycle cost. Since the EACA process examines all activities and their related costs in both operational and overhead organizational functions, environmental costs that are "hidden" by other traditional accounting information systems can be identified to produce a more complete determination of total environmental costs of products and/or processes. Linking environmental costs "hidden" in overhead to specific cost objects through the EACA process eliminates effects of arbitrary cost allocations inherent in traditional cost accounting information systems.

On an applied level, the EACA process is a workable means through which environmental costs of particular products or services can be identified and quantified for decision making. On a higher level, the EACA process can have an impact on decision making involving the elements of the environmental paradigm. For example, if new reporting regulations are being considered, then it may be useful to have knowledge of the costs already being incurred by an organization for regulatory reporting. The EACA process offers a method for providing some degree of feedback to the environmental paradigm concerning the degree of private costs expended by an organization to meet environmental requirements levied upon it. Figure 9 graphically displays the feedback process through which environmental cost data can be used in making decisions related to environmental issues. The EACA method may therefore be a vehicle through which the private costs of environmental requirements are factored into the environmental paradigm.

Figure 9:
The Environmental Paradigm with EACA Feedback



References

Cokins, G., A. Stratton, and J. Helbling. 1993. *An ABC Manager's Primer.* Montvale NJ: Institute of Management Accountants.

Ditz D., J. Ranganathan, and R. Banks. 1995. *Green Ledgers: Case Studies in Corporate Environmental Accounting.* Baltimore, MD: World Resources Institute.

Hamner, H. and C. Stinson. 1995. Managerial accounting and environmental compliance costs. *Cost Management.* (Summer): 1 – 7.

Quarles, R. 1995. *How Much Does It Really Cost To Be Green? The Need For an Environmental Cost Classification System.* Sam Houston State University Center for Business and Economic Development Working Paper 95-19A (September).

Robinson, D. Activity-based costing offers big benefits in downsizing era. *National DEFENSE.* (September): 52-53.

United States Army PBMA. 1995. *Environmental Life Cycle Cost: Sense and Destroy Armor SADARM,* (September).

United States Environmental Protection Agency, Office of Pollution Prevention and Toxics. 1995. *An Introduction to Environmental Accounting As A Business Management Tool: Key Concepts and Terms.* Washington, DC: EPA.

________________________, Office of Pollution Prevention and Toxics. 1993. *Stakeholders' Action Agenda: A report of the Workshop on Accounting and Capital Budgeting for Environmental Costs.* Washington, DC: EPA.

White, A., D. Savage, and A. Dierks. 1995. Environmental accounting principles for the substantive enterprise. *1995 TAPPI International Environmental Conference.* Atlanta, GA (May 7 – 10).

Holston
Environmental Activity Cost Analysis
Appendix C
Activities, Job Tasks, and Environmental Cost Data

For the six month period ending June 30, 1997

The following pages contain the results of the 27 storyboarding sessions that were held at Holston in order to gather the activity, job task, and environmental data necessary for this analysis.

Holston Environmental Summary by Group

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
01	Environmental Affairs	17,284	20,317	30,626	208,096	273,110	549,433	558,530	98.4%
02	Analytical Labs/Environmental Quality	31,399	45,620	15,959	13,593	70,021	176,591	558,460	31.6%
03	Explosives Manufacturing	57,083	5,121	8,370	47,005	1,334	118,914	2,277,551	5.2%
04	Explosives Finishing/Materials Handling	33,047	4,374	3,828	14,873	0	56,122	1,869,018	3.0%
05	Utilities, Area B Steam	31,255	1,003	439	57,247	7,031	96,976	701,829	13.8%
06	Organic Acids	162,826	0	0	60,076	14,384	237,286	1,000,751	23.7%
07	Utilities, Area B Water/Wastewater	196,865	53,845	170	32,683	71,793	355,355	938,517	37.9%
08	Utilities & Utilities Area A	212,859	0	9,377	37,201	10,263	269,700	1,247,567	21.6%
09	Safety	12,339	2,522	3,788	8,646	12,077	39,371	336,220	11.7%
10	Stores and Receiving	9,569	0	6	1,286	1,929	12,790	148,431	8.6%
11	Security, Fire, Emergency	102,861	0	28,227	23	10,886	141,997	1,004,002	14.1%
12	Area B Acids	156,299	0	1,528	9,170	357	167,353	937,197	17.9%
13	Development/Quality Assurance	19,090	15,301	291	4,372	874	39,929	746,116	5.4%
14	Building Maintanence	37,093	0	0	8,740	0	45,833	223,483	20.5%
15	Roads & Grounds Maintenance	73,909	1,477	7,172	69,240	11,172	162,970	606,923	26.9%
16	Electrical & Instrumental	111,631	0	36,862	3,478	0	151,971	869,398	17.5%
17	Corporate Business Planning	3,455	0	15	281	295	4,046	177,189	2.3%
18	Area Maintanence & Mechanical Services	198,944	0	0	89,526	10,253	298,723	2,004,625	14.9%
19	Employee Benefits/Personnel Services/Admin Service	761	14,186	142	8,752	5,237	29,078	638,849	4.6%
20	Purchasing	2,185	1,382	1,866	1,477	635	7,545	285,997	2.6%
21	HDC Management Team	10,465	6,424	12,141	11,206	2,975	43,210	837,995	5.2%
22	Financial Services & Payroll	6,435	98	98	0	2,590	9,221	470,871	2.0%
23	Information Systems and Services	0	0	0	0	3,823	3,823	695,066	0.5%
24	Engineering and Project Management	40,007	13,868	38,136	5,173	12,217	109,400	880,483	12.4%
I-1	Medical	6,540	0	0	7,160	0	13,700	108,531	12.6%
I-2	Contracting Services	3,053	1,587	0	0	0	4,639	646,497	0.7%
XX	Other Functions	0	0	0	0	0	0	1,470,213	0.0%
	Grand Total	1,537,255	187,124	199,040	699,302	523,256	3,145,977	22,240,304	14.1%

HolstonGroupSummary
12-12-97 11:49:36 AM

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
01	**Environmental Affairs**								
01-01	Respond to Army Request	0	0	0	0	30,323	30,323	30,323	100.0%
01-02	Comply with NHPA and NEPA	0	0	0	0	6,065	6,065	15,162	40.0%
01-03	Compliance with TSCA	1,819	1,516	0	2,426	303	6,065	6,065	100.0%
01-04	Compliance with State Solid Waste	0	0	0	30,032	0	30,032	30,032	100.0%
01-05	Compliance with RCRA	1,516	3,032	19,710	165,316	4,548	194,123	194,123	100.0%
01-06	Compliance with SARA	0	0	0	0	24,259	24,259	24,259	100.0%
01-07	Compliance with CAA	10,613	8,491	0	0	173,335	192,438	192,438	100.0%
01-08	Compliance with CWA	3,336	7,278	7,884	10,322	34,277	63,096	63,096	100.0%
01-09	Tools								
01-10	Compliance with SDWA	0	0	3,032	0	0	3,032	3,032	100.0%
Subtotal Environmental Affairs		17,284	20,317	30,626	208,096	273,110	549,433	558,530	98.4%
02	**Analytical Labs/Environmental Quality**								
02-01	Raw Materials Testing	432	0	0	1,728	0	2,161	122,823	1.8%
02-02	Perform Special/Request Sampling	11,954	12,560	864	5,237	3,899	34,514	34,514	100.0%
02-03	Perform NPDES Sampling and Testing	10,371	0	0	0	55,320	65,690	65,690	100.0%
02-04	Monitor Groundwater	5,401	33,060	15,094	0	10,803	64,358	64,358	100.0%
02-05	Building Maintanence	0	0	0	146	0	146	7,524	1.9%
02-06	Manage the Department	2,161	0	0	0	0	2,161	59,998	3.6%
02-07	Test Production Samples	1,080	0	0	6,482	0	7,562	203,553	3.7%
Subtotal Analytical Labs/Environmental Quality		31,399	45,620	15,959	13,593	70,021	176,591	558,460	31.6%
03	**Explosives Manufacturing**								
03-01	Making 581/521	1,731	0	0	346	0	2,077	96,130	2.2%
03-02	Receiving/Storage 581/521	5,528	0	0	0	0	5,528	81,687	6.8%
03-03	Analyzing 581,521, and 501/521	0	0	0	0	0	0	14,420	0.0%
03-04	Pumping from Bldg 151	3,364	0	0	0	0	3,364	33,638	10.0%
03-05	Manufacturing RDX/HMX	8,169	0	0	0	0	8,169	81,687	10.0%
03-06	Sampling	0	0	0	577	0	577	57,725	1.0%
03-07	Clean-up/Calibration	0	0	0	17,847	0	17,847	124,971	14.3%
03-08	Maintanence	3,605	0	0	3,605	0	7,210	14,420	50.0%
03-09	Processing Batch	0	0	0	0	0	0	129,789	0.0%
03-10	Recovering RDX/HDX	1,682	0	0	0	0	1,682	33,638	5.0%
03-11	Clean-up/Disposal	0	0	0	15,090	0	15,090	124,679	12.1%
03-12	Cleaning and Maintaining	0	0	0	1,374	0	1,374	92,458	1.5%
03-13	Solvent Receiving/Storage/Transferring	1,559	0	0	0	0	1,559	110,580	1.4%
03-14	Making Laquer	0	0	0	900	0	900	284,160	0.3%
03-15	Recrystalizing	0	0	0	2,452	0	2,452	355,776	0.7%
03-16	Coating	0	0	0	1,923	0	1,923	100,957	1.9%
03-17	Cleanup	0	0	0	1,557	0	1,557	69,569	2.2%
03-18	Receiving/Transferring	0	0	0	0	0	0	24,014	0.0%
03-19	Generic Activities	14,420	0	0	0	0	14,420	14,420	100.0%
03-20	Records	5,773	1,803	0	902	902	9,379	201,995	4.6%
03-21	Procedures	2,597	433	2,597	433	433	6,492	50,504	12.9%
03-22	Maintanence	8,657	0	5,773	0	0	14,429	108,208	13.3%

HolstonActivitySummary
12 12 97 11:54:14 AM

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
03-23	Managing	0	2,885	0	0	0	2,885	72,124	4.0%
	Subtotal Explosives Manufacturing	57,083	5,121	8,370	47,005	1,334	118,914	2,277,551	5.2%
04	**Explosives Finishing/Materials Handling**								
04-01	Cleaning Operating Bldgs and Equipment	0	0	0	10,936	0	10,936	123,416	8.9%
04-02	Servicing Customers	0	0	0	0	0	0	18,148	0.0%
04-03	Shipping Explosives	0	0	0	0	0	0	27,104	0.0%
04-04	Supporting Production Operations	18,810	0	0	0	0	18,810	187,457	10.0%
04-05	Improving Projects	6,015	1,640	3,828	3,828	0	15,310	98,424	15.6%
04-06	Recording Batch Data	0	0	0	109	0	109	76,552	0.1%
04-07	Safety Audits	0	0	0	0	0	0	20,307	0.0%
04-08	Handling Materials	0	1,640	0	0	0	1,640	165,783	1.0%
04-09	Storing Materials Long/Short Term	0	1,094	0	0	0	1,094	131,231	0.8%
04-10	Packaging	5,246	0	0	0	0	5,246	97,716	5.4%
04-11	Retag C4	1,062	0	0	0	0	1,062	215,768	0.5%
04-12	Incorporation	797	0	0	0	0	797	47,647	1.7%
04-13	Blending	0	0	0	0	0	0	76,552	0.0%
04-14	Drying	1,117	0	0	0	0	1,117	111,698	1.0%
04-15	Receiving and Dewatering	0	0	0	0	0	0	471,216	0.0%
	Subtotal Explosives Finishing/Materials Handlin	33,047	4,374	3,828	14,873	0	56,122	1,869,018	3.0%
05	**Utilities, Area B Steam**								
05-01	Dispose of Waste	5,012	0	0	56,297	7,031	68,340	96,775	70.6%
05-02	Make Steam	22,901	1,003	439	299	0	24,643	274,404	9.0%
05-03	Treat Water	0	0	0	615	0	615	49,241	1.2%
05-04	Receive Coal	2,991	0	0	0	0	2,991	147,748	2.0%
05-05	Make Air	281	0	0	0	0	281	63,328	0.4%
05-06	Manage Operations	70	0	0	35	0	105	70,333	0.1%
	Subtotal Utilities, Area B Steam	31,255	1,003	439	57,247	7,031	96,976	701,829	13.8%
06	**Organic Acids**								
06-01	Receiving Materials	6,630	0	0	0	0	6,630	34,443	19.2%
06-02	Operate Process	103,052	0	0	48,133	0	151,186	608,675	24.8%
06-03	Control Process	19,066	0	0	11,943	0	31,008	143,337	21.6%
06-04	Deliver Product	7,203	0	0	0	0	7,203	28,810	25.0%
06-05	Conduct Training	9,003	0	0	0	1,801	10,804	45,016	24.0%
06-06	Manage Operations	17,873	0	0	0	12,583	30,456	140,470	21.7%
	Subtotal Organic Acids	162,826	0	0	60,076	14,384	237,286	1,000,751	23.7%
07	**Utilities, Area B Water/Wastewater**								
07-01	Receive Wastewater	86,151	0	0	0	11,965	98,117	143,585	68.3%
07-02	Treat Wastewater	23,931	53,845	0	5,983	59,827	143,585	215,378	66.7%
07-03	Maintain Equipment	5,228	0	0	0	0	5,228	21,783	24.0%
07-04	Ordering Supplies	0	0	0	0	0	0	0	
07-05	Train People	0	0	0	0	0	0	0	
07-06	Manage Operations	8,637	0	54	0	0	8,691	45,884	18.9%

Holston.ActivitySummary
12 12 97 11:54:17 AM

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
07-07	Start Processing	2,861	0	116	0	0	2,977	88,779	3.4%
07-08	Processing Water	70,057	0	0	26,700	0	96,757	423,107	22.9%
Subtotal Utilities, Area B Water/Wastewater		196,865	53,845	170	32,683	71,793	355,355	938,517	37.9%
08	**Utilities & Utilities Area A**								
08-01	Dispose of Waste	13,437	0	0	34,066	0	47,503	58,926	80.6%
08-02	Make Steam	117,216	0	4,035	0	3,051	124,303	545,379	22.8%
08-03	Treat Water	71,254	0	0	3,135	0	74,390	416,842	17.8%
08-04	Receive Coal	0	0	0	0	1,870	1,870	110,621	1.7%
08-05	Make Air	0	0	0	0	0	0	8,958	0.0%
08-06	Manage Operations	10,951	0	5,342	0	5,342	21,635	106,841	20.3%
Subtotal Utilities & Utilities Area A		212,859	0	9,377	37,201	10,263	269,700	1,247,567	21.6%
09	**Safety**								
09-01	Monitor Safety Process	2,354	2,522	2,051	0	0	6,926	92,460	7.5%
09-02	Communicate Safety Information	1,664	0	0	0	3,362	5,026	28,579	17.6%
09-03	Manage Safety Process	3,429	0	0	0	925	4,354	114,315	3.8%
09-04	Neutralize Explosives	4,035	0	0	7,397	6,724	18,156	23,535	77.1%
09-05	Respond to emergencies	0	0	1,064	1,064	1,066	3,194	20,173	15.8%
09-06	Comply with Regulations	336	0	672	168	0	1,177	18,492	6.4%
09-07	Insuring Regulatory Compliance	521	0	0	17	0	538	38,665	1.4%
Subtotal Safety		12,339	2,522	3,788	8,646	12,077	39,371	336,220	11.7%
10	**Stores and Receiving**								
10-01	Receive Materials	208	0	0	0	0	208	49,087	0.4%
10-02	Control Stores	4,583	0	0	0	0	4,583	62,529	7.3%
10-03	Recycle Materials	64	0	0	1,286	0	1,350	12,272	11.0%
10-04	Manage Store and Receiving	79	0	0	0	0	79	14,258	0.6%
10-05	Prepare Required Reports	1,935	0	6	0	1,929	3,870	5,143	75.3%
10-06	Inspect Facilities and Equipment	2,700	0	0	0	0	2,700	5,143	52.5%
Subtotal Stores and Receiving		9,569	0	6	1,286	1,929	12,790	148,431	8.6%
11	**Security, Fire, Emergency**								
11-01	Manage Operations	3,030	0	23	23	319	3,396	230,513	1.5%
11-02	Secure Facilities	76,055	0	3,026	0	0	79,081	433,737	18.2%
11-03	Report Activities	0	0	0	0	10,567	10,567	74,664	14.2%
11-04	Respond to Emergency	0	0	25,177	0	0	25,177	39,440	63.8%
11-05	Maintain Fire Protection Equipment	0	0	0	0	0	0	70,448	0.0%
11-06	Inspect Facilities and Equipment	5,812	0	0	0	0	5,812	84,751	6.9%
11-07	Train Personnel	17,964	0	0	0	0	17,964	70,448	25.5%
Subtotal Security, Fire, Emergency		102,861	0	28,227	23	10,886	141,997	1,004,002	14.1%
12	**Area B Acids**								
12-01	Manage Operations	32,633	0	1,528	815	357	35,333	220,067	16.1%
12-02	Conduct Training	8,151	0	0	204	0	8,355	36,679	22.8%
12-03	Produce Nitric Acid/Ammonium Nitrate	72,730	0	0	0	0	72,730	368,694	19.8%

HolstonActivitySummary
12 12 97 11:54:20 AM

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
12-04	Recover Acetic Acid	42,785	0	0	8,151	0	50,936	313,756	16.2%
	Subtotal Area B Acids	156,299	0	1,528	9,170	357	167,353	937,197	17.9%
13	Development/Quality Assurance								
13-01	Providing Technical Support	3,352	4,226	0	0	0	7,578	119,495	6.3%
13-02	Develop/Update Analytical Methods	0	7,578	0	0	0	7,578	104,923	7.2%
13-03	Train Personnel	0	0	0	0	0	0	17,487	0.0%
13-04	Provide Administrative Support	291	291	291	291	0	1,166	49,547	2.4%
13-05	Assure Product Quality	1,312	0	0	0	0	1,312	288,537	0.5%
13-06	Analyze Samples	0	1,457	0	2,915	0	4,372	46,632	9.4%
13-07	Develop Products/Prcesses	14,135	1,749	0	1,166	874	17,924	119,495	15.0%
	Subtotal Development/Quality Assurance	19,090	15,301	291	4,372	874	39,929	746,116	5.4%
14	Building Maintanence								
14-01	Dispose Waste	0	0	0	8,740	0	8,740	9,988	87.5%
14-02	Process Waste	3,121	0	0	0	0	3,121	3,746	83.3%
14-03	Conduct Maintanence	26,506	0	0	0	0	26,506	137,336	19.3%
14-04	Get Material	0	0	0	0	0	0	9,988	0.0%
14-05	Prepare for Maintanence Work	4,994	0	0	0	0	4,994	27,467	18.2%
14-06	Attend Training Meetings	936	0	0	0	0	936	11,237	8.3%
14-07	Manage Building Maintanence	1,536	0	0	0	0	1,536	23,722	6.5%
	Subtotal Building Maintanence	37,093	0	0	8,740	0	45,833	223,483	20.5%
15	Roads & Grounds Maintenance								
15-01	Coordinate Resources	0	1,477	0	0	633	2,109	10,547	20.0%
15-02	Operate Landfill	26,027	0	0	55,635	8,008	89,670	159,741	56.1%
15-03	Clean Area	8,437	0	0	12,656	0	21,093	25,312	83.3%
15-04	Deliver Materials	11,812	0	0	0	0	11,812	65,390	18.1%
15-05	Contain Spills	4,219	0	0	0	0	4,219	4,219	100.0%
15-06	Operate Equipment	0	0	5,062	0	0	5,062	37,968	13.3%
15-07	Maintain Roads	0	0	0	0	0	0	61,171	0.0%
15-08	Maintain Grounds	0	0	0	0	0	0	71,718	0.0%
15-09	Prepare for Work	0	0	0	0	0	0	4,219	0.0%
15-10	Control Pests and Vegitation	21,937	0	0	0	2,109	24,047	73,827	32.6%
15-11	Attend Training	0	0	0	0	0	0	10,547	0.0%
15-12	Coordinate Daily Work	1,477	0	2,109	949	422	4,957	82,265	6.0%
	Subtotal Roads & Grounds Maintenance	73,909	1,477	7,172	69,240	11,172	162,970	606,923	26.9%
16	Electrical & Instrumental								
16-01	Dispose of Materials and Parts	0	0	0	3,478	0	3,478	10,433	33.3%
16-02	Procure Parts/Equipment	261	0	1,391	0	0	1,652	31,296	5.3%
16-03	Maintain UPS	869	0	0	0	0	869	12,172	7.1%
16-04	Calibrate Equipmet	37,210	0	0	0	0	37,210	149,536	24.9%
16-05	Maintain Facilities/Equipment	56,946	0	35,471	0	0	92,417	438,176	21.1%
16-06	Prepare for Work	6,955	0	0	0	0	6,955	114,761	6.1%
16-07	Train Personnel	9,389	0	0	0	0	9,389	60,858	15.4%

HolstonActivitySummary
12/12/97 11:54:23 AM

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
16-08	Manage Operations	0	0	0	0	0	0	52,164	0.0%
Subtotal Electrical & Instrumental		111,631	0	36,862	3,478	0	151,971	869,396	17.5%
17	Corporate Business Planning								
17-01	Coordinate Special Projects	886	0	0	0	0	886	20,672	4.3%
17-02	Coordinate Facilities	30	0	0	0	0	30	14,766	0.2%
17-03	Plan Production	783	0	15	59	0	856	53,157	1.6%
17-04	Receive Training	177	0	0	0	0	177	8,859	2.0%
17-05	Market to Third Parties	989	0	0	221	295	1,506	38,391	3.9%
17-06	Develop Business	591	0	0	0	0	591	17,719	3.3%
17-07	Present Meetings	0	0	0	0	0	0	23,625	0.0%
Subtotal Corporate Business Planning		3,455	0	15	281	295	4,046	177,189	2.3%
18	Area Maintanence & Mechanical Services								
18-01	Maintain Equipment	62,848	0	0	0	0	62,848	261,928	24.0%
18-02	Perform Mechanical Functions	70,550	0	0	22,315	0	92,865	882,836	10.5%
18-03	Procure Material	0	0	0	0	0	0	238,084	0.0%
18-04	Handle Waste Material	24,419	0	0	67,212	0	91,630	185,817	49.3%
18-05	Prepare for Jobs	2,298	0	0	0	0	2,298	80,414	2.9%
18-06	Manage Paperwork	1,867	0	0	0	0	1,867	192,419	1.0%
18-07	Train Personnel	36,962	0	0	0	10,253	47,215	163,127	28.9%
Subtotal Area Maintanence & Mechanical Servi		196,944	0	0	89,526	10,253	296,723	2,004,625	14.9%
19	Employee Benefits/Personnel Services/Admin Service								
19-01	Manage Government Property	212	301	35	1,460	336	2,345	77,131	3.0%
19-02	Attend Training Sessions	513	0	0	0	0	513	21,232	2.4%
19-03	Administer Emploee Benefit Programs/Plans	0	0	0	0	0	0	206,725	0.0%
19-04	Provide Personnel Services	0	0	0	0	0	0	102,621	0.0%
19-05	Support Process Improvement	0	0	106	0	35	142	17,693	0.8%
19-06	Maintain Facility Inventory	0	0	0	4,991	0	4,991	53,063	9.4%
19-07	Purchase Operating Supplies	35	0	0	0	0	35	22,965	0.2%
19-08	Provide Printing Services	0	0	0	531	0	531	17,693	3.0%
19-09	Respond to Government Requests	0	0	0	0	4,335	4,335	23,001	18.8%
19-10	Manage Daily Activities	0	13,886	0	1,769	531	16,186	96,703	16.7%
Subtotal Employee Benefits/Personnel Services		761	14,186	142	8,752	5,237	29,078	638,849	4.6%
20	Purchasing								
20-01	Comply w/ Rules and Regulations	0	0	0	0	0	0	22,244	0.0%
20-02	Subcontract Goods and Services	0	715	715	254	0	1,684	84,210	2.0%
20-03	Procure Goods and Services	2,185	667	1,151	1,223	635	5,861	146,176	4.0%
20-04	Certify Vendors	0	0	0	0	0	0	12,711	0.0%
20-05	Attend Meetings	0	0	0	0	0	0	7,944	0.0%
20-06	Maintain Purchasing	0	0	0	0	0	0	12,711	0.0%
Subtotal Purchasing		2,185	1,382	1,866	1,477	635	7,545	285,997	2.6%

HolstonActivitySummary
12 12 97 11:54:27 AM

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
21	**HDC Management Team**								
21-01	Plan Operations	3,910	2,514	3,910	3,910	2,514	16,758	192,739	8.7%
21-02	Monitor Results of Plans	6,068	1,396	5,230	4,295	461	17,450	284,918	6.1%
21-03	Manage Operations	487	2,514	3,001	3,001	0	9,003	360,338	2.5%
Subtotal HDC Management Team		10,465	6,424	12,141	11,206	2,975	43,210	837,995	5.2%
22	**Financial Services & Payroll**								
22-01	Analyze Accounts	0	0	0	0	0	0	43,163	0.0%
22-02	Process Payroll	3,728	0	0	0	0	3,728	113,794	3.3%
22-03	Pay Bills	1,079	0	98	0	1,177	2,354	70,631	3.3%
22-04	Respond to Auditors	0	98	0	0	0	98	21,582	0.5%
22-05	Prepare Reports	0	0	0	0	432	432	51,011	0.8%
22-06	Close Monthly	0	0	0	0	392	392	60,821	0.6%
22-07	Estimate Costs	687	0	0	0	490	1,177	47,087	2.5%
22-08	Develop Software	0	0	0	0	98	98	13,734	0.7%
22-09	Manage Teams	942	0	0	0	0	942	49,049	1.9%
Subtotal Financial Services & Payroll		6,435	98	98	0	2,590	9,221	470,871	2.0%
23	**Information Systems and Services**								
23-01	Manage Inventory	0	0	0	0	0	0	60,818	0.0%
23-02	Operate System	0	0	0	0	2,896	2,896	115,844	2.5%
23-03	Support Applications	0	0	0	0	927	927	263,546	0.4%
23-04	Maintain Computing Environment	0	0	0	0	0	0	139,013	0.0%
23-05	Conduct Dept. Functions	0	0	0	0	0	0	28,961	0.0%
23-06	Develop Employee Skills	0	0	0	0	0	0	34,753	0.0%
23-07	Evaluate Heads	0	0	0	0	0	0	52,130	0.0%
Subtotal Information Systems and Services		0	0	0	0	3,823	3,823	695,066	0.5%
24	**Engineering and Project Management**								
24-01	Support Operations	10,456	0	7,924	1,101	1,761	21,242	193,706	11.0%
24-02	Design Projects	24,874	13,868	13,868	3,632	0	56,241	345,589	16.3%
24-03	Manage Projects	3,797	0	16,344	440	10,456	31,037	184,901	16.8%
24-04	Manage Dept.	880	0	0	0	0	880	156,286	0.6%
Subtotal Engineering and Project Management		40,007	13,868	38,136	5,173	12,217	109,400	880,483	12.4%
I-1	**Medical**								
I-1-01	Physician Clinical Duties	110	0	0	0	0	110	1,103	10.0%
I-1-02	Nursing Clinical Duties	260	0	0	1,562	0	1,823	26,037	7.0%
I-1-03	Clinical Duties	1,464	0	0	814	0	2,278	33,010	6.9%
I-1-04	Meetings	0	0	0	0	0	0	441	0.0%
I-1-05	Technician Administrative Duties	0	0	0	78	0	78	10,415	0.8%
I-1-06	Testing	2,617	0	0	2,617	0	5,234	15,596	33.6%
I-1-07	Voluntary Exams	1,412	0	0	1,412	0	2,824	5,649	50.0%
I-1-08	Required Examinations	513	0	0	513	0	1,027	5,424	18.9%
I-1-09	Testings for Drugs/Alcohol	163	0	0	163	0	326	10,856	3.0%

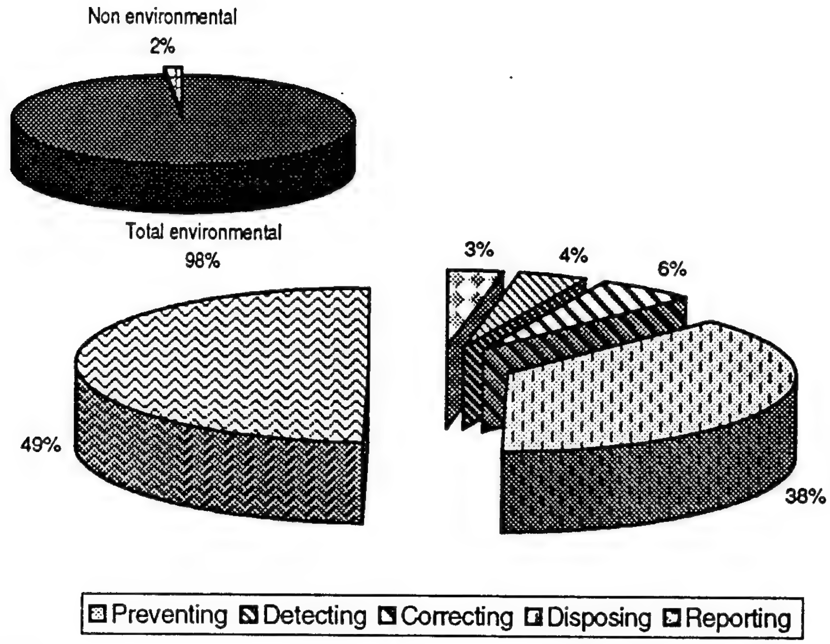
HolstonActivitySummary
12/12/97 11:54:29 AM

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
Subtotal Medical		6,540	0	0	7,160	0	13,700	108,531	12.6%
I-2	Contracting Services								
I-2-01	Administer Contracts	628	198	0	0	0	826	52,891	1.6%
I-2-02	Setup Contract	331	66	0	0	0	397	19,834	2.0%
I-2-03	Administer Standing Contracts	0	1,322	0	0	0	1,322	52,891	2.5%
I-2-04	Janitorial	820	0	0	0	0	820	273,293	0.3%
I-2-05	Laundry	1,080	0	0	0	0	1,080	54,023	2.0%
I-2-06	Operate Railroad	194	0	0	0	0	194	193,565	0.1%
I-2-07	Mow Grass	0	0	0	0	0	0	0	
Subtotal Contracting Services		3,053	1,587	0	0	0	4,639	646,497	0.7%
XX	Other Functions								
XX-01	Health + Taxes	0	0	0	0	0	0	1,470,213	0.0%
Subtotal Other Functions		0	0	0	0	0	0	1,470,213	0.0%
	Grand Total	1,537,255	187,124	199,040	699,302	523,256	3,145,977	22,240,304	14.1%

HolstonActivitySummary
12/12/97 11:54:31 AM

Environmental Affairs



Session Number 01
Group Environmental Affairs
Organization Support

Category	Cost	% of Total	% of Environmental
Preventing	17,284	3.1%	3.1%
Detecting	20,317	3.6%	3.7%
Correcting	30,626	5.5%	5.6%
Disposing	208,096	37.3%	37.9%
Reporting	273,110	48.9%	49.7%
Total environmental	549,433	98.4%	100.0%
Non environmental	9,097	1.6%	
Cost	558,530	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
01	Environmental Affairs								
01-01	Respond to Army Request	0	0	0	0	30,323	30,323	30,323	100.0%
01-02	Comply with NHPA and NEPA	0	0	0	0	6,065	6,065	15,162	40.0%
01-03	Compliance with TSCA	1,819	1,516	0	2,426	303	6,065	6,065	100.0%
01-04	Compliance with State Solid Waste	0	0	0	30,032	0	30,032	30,032	100.0%
01-05	Compliance with RCRA	1,516	3,032	19,710	165,316	4,548	194,123	194,123	100.0%
01-06	Compliance with SARA	0	0	0	0	24,259	24,259	24,259	100.0%
01-07	Compliance with CAA	10,613	8,491	0	0	173,335	192,438	192,438	100.0%
01-08	Compliance with CWA	3,336	7,278	7,884	10,322	34,277	63,096	63,096	100.0%
01-09	Tools								
01-10	Compliance with SDWA	0	0	3,032	0	0	3,032	3,032	100.0%
Subtotal Environmental Affairs		17,284	20,317	30,626	208,096	273,110	549,433	558,530	98.4%

Holston Activity and Task Summary

Session 01 Environmental Affairs

Date	7/28/97	5 Participants	Bob Lowe, Patty Evans, Vivian Brown, John Eiklor, George Fletcher	Observers	Keith, Glenn, Ennis, Alan, Mark
Time	8:00	FTE:	5 109 Years Experience	Note	Blue Dot: Labor Orange Dot: Subcontracting Yellow Dot: Enironmental Permits and Fees Green Dot: Environmental

Activity **01-01**

Respond to Army Request

Activity Note

Activity Driver Candidates None

	FTE	Cost	People Time	Sub Contract	Permits /Fees	-	-	Environ mental	Prevent Ing	Detect ing	Correct Ing	Dispos Ing	Report Ing
1 Support Government Studies by USACHPPM	0.0		0	0	0	0	0	100	0	100	0	0	0
2 Prepare ACTS Report	0.1	3,032	0.5	0	0	0	0	100	0	0	0	0	100
3 Prepare/Supply Data to Installation Plan	0.1	3,032	0.5	0	0	0	0	100	0	0	0	0	100
4 Respond to Letters/Requests from Gov't Staff	0.4	18,194	3	0	0	0	0	100	0	0	0	0	100
5 Coordinate 1383/A106 Updates	0.1	3,032	0.5	0	0	0	0	100	0	0	0	0	100
6 Prepare DSERTS Report	0.1	3,032	0.5	0	0	0	0	100	0	0	0	0	100
7 High Risk Areas Identification	0.0		0	0	0	0	0		0	0	0	0	0
Activity Total	0.6	30,323	5	0	0	0	0						
		30,323	100.0%					100.0%	0	0	0	0	30,323

Activity **01-02**

Comply with NHPA and NEPA

Activity Note

Activity Driver Candidates Facility Usage

	FTE	Cost	People Time	Sub Contract	Permits /Fees	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Coordinate Resolution of Historical Issues w/ State Hist Preservation Officer (S	0.1	6,065	1	0	0	0	0		0	0	0	0	0
2 Implement Historical Regulations	0.1	3,032	0.5	0	0	0	0		0	0	0	0	0
3 Coordinate Archaeological Study	0.0		0	0	0	0	0		0	0	0	0	0
4 Prepare NEPA Documents	0.1	6,065	1	0	0	0	0	100	0	0	0	0	100
5 Type Record of Enviromental Consideration, FONSI & Follow up on Approvals	0.0		0	0	0	0	0	100	0	0	0	0	100
Activity Total	0.3	15,162	2.5	0	0	0	0						
		6,065	40.0%					40.0%	0	0	0	0	6,065

Holston Activity and Task Summary

Session 01 Environmental Affairs

Activity **01-03**

Compliance with TSCA

Activity Note: Chemical Inventory

	FTE	Cost	People Time	Sub Contract	Permits /Fees	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
			Activity Driver Candidates										
1 Compliance with TSCA Regulations	0.1	3,032	0.5	0	0	0	0	100	50	50	0	0	0
2 Compliance with PCB's Disposal Regulations	0.1	3,032	0.5	0	0	0	0	100	10	0	0	80	10
Activity Total	0.1	6,065	1	0	0	0	0						
		6,065	100.0%					100.0%	1,819	1,516	0	2,426	303

Activity **01-04**

Compliance with State Solid Waste

Activity Note: Solid Waste Disposal

	FTE	Cost	People Time	Sub Contract	Permits /Fees	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
			Activity Driver Candidates										
1 Provide Guidance to Departments on Management of Solid Waste	0.1	3,032	0.5	0	0	0	0	100	0	0	0	100	0
2 Support Landfill Start-up and Operation	0.2	17,903	1.5	0	0.5	0	0	100	0	0	0	100	0
3 Support Landfill Closure (Flyash and Sanitary)	0.2	9,097	1.5	0	0	0	0	100	0	0	0	100	0
4 Prepare Wastewide Report	0.0		0	0	0	0	0	100	0	0	0	0	100
Activity Total	0.4	30,032	3.5	0	0.5	0	0						
		30,032	100.0%		100.0%			100.0%	0	0	0	30,032	0

Activity **01-05**

Compliance with RCRA

Activity Note

	FTE	Cost	People Time	Sub Contract	Permits /Fees	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
			Activity Driver Candidates										
1 Prepare Annual Haz Waste Minimization Report	0.1	3,032	0.5	0	0	0	0	100	0	0	0	0	100
2 Oversee BLDG 105 Solvent Vapor Extraction System Operations and Reports	0.1	3,032	0.5	0	0	0	0	100	0	0	50	0	50
3 Coordinate/Oversee Hazardous Waste Shipments	0.1	3,032	0.5	0	0	0	0	100	0	0	0	100	0
4 Prepare Subcontract Specifications for Environmental Subcontracted Efforts	0.1	6,065	1	0	0	0	0	100	0	0	100	0	0
5 Coordinate Subcontracted Part B Permit Application Submission	0.3	151,962	2	1	0	0	0	100	0	0	0	100	0
6 Support Environmental Based Projects: Restor/Remediation, Construc, & Investigat	0.1	6,065	1	0	0	0	0	100	0	50	50	0	0
7 Inspect Hazardous Waste Storage Sites	0.0		0	0	0	0	0	100	50	0	0	50	0
8 Coordinate Subcontracted Solvent Burn Tank Closure	0.2	9,097	1.5	0	0	0	0	100	0	0	100	0	0

	FTE	Cost	People Time	Sub Contract	Permits /Fees	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
9 Calculate Haz Waste Fees	0.0	8,806	0	0	0.5	0	0	100	0	0	0	100	0
10 Provide Guidance to Dept. on Management of Hazardous Waste	0.1	3,032	0.5	0	0	0	0	100	50	0	0	50	0
Activity Total	0.9	194,123	7.5	1	0.5	0	0						
		194,123	100.0%	100.0%	100.0%			100.0%	1,516	3,032	19,710	165,316	4,548

Activity **01-06**

Compliance with SARA

	FTE	Cost	People Time	Sub Contract	Permits /Fees	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
			Activity Driver Candidates			Activity Note		Chemical Usage					
1 Prepare SARA 313 Report	0.3	12,129	2	0	0	0	0	100	0	0	0	0	100
2 Prepare SARA 312 Report	0.3	12,129	2	0	0	0	0	100	0	0	0	0	100
Activity Total	0.5	24,259	4	0	0	0	0						
		24,259	100.0%					100.0%	0	0	0	0	24,259

Activity **01-07**

Compliance with CAA

	FTE	Cost	People Time	Sub Contract	Permits /Fees	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
			Activity Driver Candidates			Activity Note		Chemical Usage					
1 Provide Training on HR Regulations/Compliance to Various HDC Dept.	0.0		0	0	0	0	0	100	100	0	0	0	0
2 Compliance with Asbestos Regulations	0.0		0	0	0	0	0	100	100	0	0	0	0
3 Prepare Asbestos Notification Reports and Burial Notices to the State	0.1	6,065	1	0	0	0	0	100	0	0	0	0	100
4 Perform Internal Air Audits of Stack Sources	0.1	3,032	0.5	0	0	0	0	100	100	0	0	0	0
5 Address Title V Permit Approval Issues	0.1	3,032	0.5	0	0	0	0	100	50	0	0	0	50
6 Complete Training for Risk Management Plan Preparation	0.1	3,032	0.5	0	0	0	0	100	100	0	0	0	0
7 Implementation of Clean Air Act/Title V Permit	0.4	21,226	3.5	0	0	0	0	100	0	40	0	0	60
8 Coordinate State Air Audit Annually	0.1	3,032	0.5	0	0	0	0	100	100	0	0	0	0
9 Coordinate Resolutions of Air Permit/Title V Ques w/ the State Air Regulations	0.1	6,065	1	0	0	0	0	100	0	0	0	0	100
10 Calculate Air Permit Fees Annually	0.1	143,921	0.5	0	8	0	0	100	0	0	0	0	100
11 Maintain Awareness of Risk Management Plan (RMP) Regulations for Prep of RMP	0.1	3,032	0.5	0	0	0	0	100	0	0	0	0	100
Activity Total	1.1	192,438	8.5	0	8	0	0						
		192,438	100.0%		100.0%			100.0%	10,613	8,491	0	0	173,335

Holston Activity and Task Summary

Session 01 Environmental Affairs

Activity **01-08**

Compliance with CWA

Activity Note

Activity Driver Candidates Chemial Usage

	FTE	Cost	People Time	Sub Contract	Permits /Fees	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Water Issues	0.1	6,065	1	0	0	0	0	100	30	30	0	0	40
2 Spill Response	0.1	3,032	0.5	0	0	0	0	100	0	30	30	0	40
3 NPDES Isues	0.1	20,643	0.5	0	1	0	0	100	0	0	0	50	50
4 Review Groundwater Monitoring Data	0.1	3,032	0.5	0	0	0	0	100	0	0	0	0	100
5 Satistify NPDES Regulations	0.1	3,032	0.5	0	0	0	0	100	0	0	80	0	20
6 SPCC Plan Review	0.1	6,065	1	0	0	0	0	100	25	25	25	0	25
7 BMP(Best Management Practices) Preparation and Revision	0.2	9,097	1.5	0	0	0	0	100	0	0	0	0	100
8 Respond to Various Surveys (Water Use, Capacities, etc.)	0.1	3,032	0.5	0	0	0	0	100	0	0	0	0	100
9 Assure NPDES Permit Compliance	0.1	6,065	1	0	0	0	0	100	0	0	50	0	50
10 Assure NPDES Discharge Points are Identified and Maintained	0.1	3,032	0.5	0	0	0	0	100	0	100	0	0	0
Activity Total	0.9	63,096	7.5	0	1	0	0						
		63,096	100.0%		100.0%			100.0%	3,336	7,278	7,884	10,322	34,277

Activity **01-09**

Tools

Activity Note

Activity Driver Candidates None

	FTE	Cost	People Time	Sub Contract	Permits /Fees	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Provide Environmental Training Required	0.0		0	0	0	0	0		0	0	0	0	0
2 Provide State Notifications	0.0		0	0	0	0	0		0	0	0	0	0
3 Identify Corrective Actions for NOV's (State and Federal)	0.0		0	0	0	0	0		0	0	0	0	0
4 Aid State and Federal in On-Site Studies	0.0		0	0	0	0	0		0	0	0	0	0
5 Environmental Audits	0.0		0	0	0	0	0		0	0	0	0	0
6 Update SOP's (EA)	0.0		0	0	0	0	0		0	0	0	0	0
7 Environmental Program Manual Update	0.0		0	0	0	0	0		0	0	0	0	0
8 Maintain Audit File in EA	0.0		0	0	0	0	0		0	0	0	0	0
9 Type Environmental Program Manuals, EPM, ADM	0.0		0	0	0	0	0		0	0	0	0	0
10 Maintain Distrobution on all Environmental Manuals	0.0		0	0	0	0	0		0	0	0	0	0
11 Track Costs for Environmental Efforts	0.0		0	0	0	0	0		0	0	0	0	0
12 Filing EA Correspondence	0.0		0	0	0	0	0		0	0	0	0	0
13 Coordinate Regulator Visits	0.0		0	0	0	0	0		0	0	0	0	0
14 Review Outgoing Work from the Group	0.0		0	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 01 Environmental Affairs

	FTE	Cost	People Time	Sub Contract	Permits /Fees	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
15 Escort Regulators	0.0		0	0	0	0	0		0	0	0	0	0
16 Provide Environmental Updates to Management Weekly, Monthly	0.0		0	0	0	0	0		0	0	0	0	0
17 Coordinate Incoming Work/Issues	0.0		0	0	0	0	0		0	0	0	0	0
18 Maintain Awareness of Current Regulations	0.0		0	0	0	0	0		0	0	0	0	0
Activity Total	0.0		0	0	0	0	0						

Activity **01-10**

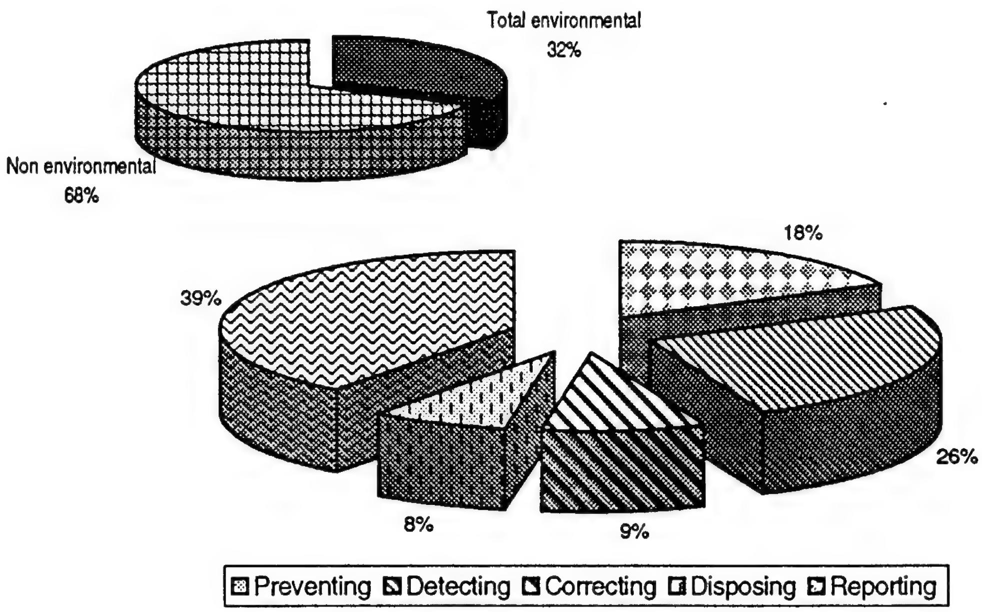
Compliance with SDWA

Activity Note

Activity Driver Candidates Solid Waste Disposal

	FTE	Cost	People Time	Sub Contract	Permits /Fees	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Drinking Water Well Issues	0.1	3,032	0.5	0	0	0	0	100	0	0	100	0	0
Activity Total	0.1	3,032	0.5	0	0	0	0						
		3,032	100.0%					100.0%	0	0	3,032	0	0
Session Total	5.0	558,530	40	1	10	0	0						
		549,433	96.3%	100.0%	100.0%				17,284	20,317	30,626	208,096	273,110

Analytical Labs/Environmental Quality



Session Number	02
Group	Analytical Labs/Environmental Quality
Organization	Support

Category	Cost	% of Total	% of Environmental
Preventing	31,399	5.6%	17.8%
Detecting	45,620	8.2%	25.8%
Correcting	15,959	2.9%	9.0%
Disposing	13,593	2.4%	7.7%
Reporting	70,021	12.5%	39.7%
Total environmental	176,591	31.6%	100.0%
Non environmental	381,868	68.4%	
Cost	558,460	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
02	Analytical Labs/Environmental Quality								
02-01	Raw Materials Testing	432	0	0	1,728	0	2,161	122,823	1.8%
02-02	Perform Special/Request Sampling	11,954	12,560	864	5,237	3,899	34,514	34,514	100.0%
02-03	Perform NPDES Sampling and Testing	10,371	0	0	0	55,320	65,690	65,690	100.0%
02-04	Monitor Groundwater	5,401	33,060	15,094	0	10,803	64,358	64,358	100.0%
02-05	Building Maintanence	0	0	0	146	0	146	7,524	1.9%
02-06	Manage the Department	2,161	0	0	0	0	2,161	59,998	3.6%
02-07	Test Production Samples	1,080	0	0	6,482	0	7,562	203,553	3.7%
Subtotal Analytical Labs/Environmental Qualit		31,399	45,620	15,959	13,593	70,021	176,591	558,460	31.6%

Holston Activity and Task Summary

Session 02 Analytical Labs/Environmental Quality

Date	7/28/97	5 Participants	Wayne Yates, Bobby Henard, Les Stevens, Jim Kelly, Todd Hayes	Observers	Alan, Ennis, Keith, Glenn, Mark
Time	1:00 p.m.	FTE:	22 108 Years Experience	Note	Red Dot: Operating Supplies Blue Dot: Labor Green Dot: Environmental Activity Orange Dot: Subcontractors

Activity **02-01**

Raw Materials Testing

Activity Note

Activity Driver Candidates Products, Products and Oil

	FTE	Cost	People Time	Oper Supplies	Sub Contracts	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
2 Check for Incoming Samples	0.1	3,241	1.5	0	0	0	0		0	0	0	0	0
3 Setup and Warm-up any Equipment	0.3	6,482	3	0	0	0	0		0	0	0	0	0
4 Perform Standard Analysis When and Where Needed	0.3	6,773	3	1	0	0	0		0	0	0	0	0
5 Perform Most Needed Analysis	1.7	42,506	19	5	0	0	0		0	0	0	0	0
6 Relieve EQ Lab Personnel	0.3	6,482	3	0	0	0	0		0	0	0	0	0
7 Decipher ASM's for Newer Employees	0.2	4,321	2	0	0	0	0		0	0	0	0	0
8 Prepare Needed Solutions for Test	0.6	14,128	6	4	0	0	0		0	0	0	0	0
9 Deliver Solutions to Area Buildings	0.3	6,482	3	0	0	0	0		0	0	0	0	0
10 Check Phone Messages for Needed Solutions in Area	0.1	2,161	1	0	0	0	0		0	0	0	0	0
11 Log Completed Analysis into Computer	0.6	12,963	6	0	0	0	0		0	0	0	0	0
12 Help Train Lab Employees	0.3	6,482	3	0	0	0	0		0	0	0	0	0
13 Shut Equipment Down, Lights and Power Off	0.1	2,161	1	0	0	0	0		0	0	0	0	0
14 Write ASM's	0.2	4,321	2	0	0	0	0		0	0	0	0	0
15 Chemical Handling	0.1	2,161	1	0	0	0	0		0	0	0	0	0
16 Chemical Disposal	0.1	2,161	1	0	0	0	0	100	20	0	0	80	0
Activity Total	5.1	122,823	55.5	10	0	0	0						
		2,161	1.8%	0.0%				1.8%	432	0	0	1,728	0

Activity **02-02**

Perform Special/Request Sampling

Activity Note

Activity Driver Candidates Solvents and Explosives, Operating Dept., Environmental Affairs, Tennesee

	FTE	Cost	People Time	Oper Supplies	Sub Contracts	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Take Waste Oil Samples	0.0	4,415	0.5	1	2	0	0	100	50	0	0	50	0
2 Take Paint Samples	0.0	2,602	0.5	0	1	0	0	100	50	0	0	50	0
3 Burning Ground Ash Sampling	0.0	2,602	0.5	0	1	0	0	100	100	0	0	0	0
4 Sample Stormwater Run-off	0.0	2,602	0.5	0	1	0	0	100	0	0	0	0	100

Holston Activity and Task Summary

Session 02 Analytical Labs/Environmental Quality

	FTE	Cost	People Time	Oper Supplies	Sub Contracts	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
5 Take Soil Samples	0.0	2,602	0.5	0	1	0	0	100	0	100	0	0	0
6 Air Sampling	0.0	1,080	0.5	0	0	0	0	100	0	100	0	0	0
7 Analyze Waste Water Facility Sludge	0.2	5,843	2	0	1	0	0	100	100	0	0	0	0
8 Coordinate Sampling	0.1	2,161	1	0	0	0	0	100	0	20	0	80	0
9 Maintain all Environmental Files	0.0	1,080	0.5	0	0	0	0	100	0	0	0	0	100
10 Collect Colliform Samples	0.0	2,602	0.5	0	1	0	0	100	0	100	0	0	0
11 Special Water Samples	0.2	5,843	2	0	1	0	0	100	0	100	0	0	0
12 Spill Response	0.0	1,080	0.5	0	0	0	0	100	0	0	80	0	20
Activity Total	0.9	34,514	9.5	1	9	0	0						
		34,514	100.0%	100.0%	100.0%			100.0%	11,954	12,560	864	5,237	3,899

Activity **02-03**

Perform NPDES Sampling and Testing

Activity Note

Activity Driver Candidates Nitrates, Tennesee

	FTE	Cost	People Time	Oper Supplies	Sub Contracts	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 NPDES Testing	0.7	17,078	7.5	3	0	0	0	100	0	0	0	0	100
2 NPDES Permits	0.3	6,482	3	0	0	0	0	100	0	0	0	0	100
3 Collect Metals/Cyanide Samples for NPDES	0.0	1,080	0.5	0	0	0	0	100	0	0	0	0	100
4 NPDES Cooling Water Analysis	0.2	4,321	2	0	0	0	0	100	0	0	0	0	100
5 Toxis for NPDES	0.0	0	0	0	0	0	0	100	0	0	0	0	100
6 Cooling Water Testing and Sampling	0.4	8,642	4	0	0	0	0	100	0	0	0	0	100
7 PH Station Monitoring	0.6	12,963	6	0	0	0	0	100	80	0	0	0	20
8 NPDES- Sanitary(216) Analysis	0.6	15,124	7	0	0	0	0	100	0	0	0	0	100
9 Maintain Rain Gauge	0.0	0	0	0	0	0	0	100	0	0	0	0	100
Activity Total	2.8	65,690	30	3	0	0	0						
		65,690	100.0%	100.0%				100.0%	10,371	0	0	0	55,320

Activity **02-04**

Monitor Groundwater

Activity Note

Activity Driver Candidates Historic Use, EA, Tennesee

	FTE	Cost	People Time	Oper Supplies	Sub Contracts	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Order Groundwater Equipment	0.0	2,245	0.5	4	0	0	0	100	0	70	30	0	0
2 Solvent and Burn Tank Monitoring	0.1	3,241	1.5	0	0	0	0	100	0	0	100	0	0
3 Groundwater Reports	0.3	6,482	3	0	0	0	0	100	0	0	0	0	100
4 Maintain Field Data Log Sheets	0.2	4,321	2	0	0	0	0	100	0	0	0	0	100
5 Training for Groundwater	0.2	5,401	2.5	0	0	0	0	100	100	0	0	0	0
6 Testing Groundwater	0.1	19,982	1.5	0	11	0	0	100	0	70	30	0	0
7 Calibrate and Check Equipment for Use	0.2	4,321	2	0	0	0	0	100	0	70	30	0	0

Holston Activity and Task Summary

Session 02 Analytical Labs/Environmental Quality

	FTE	Cost	People Time	Oper Supplies	Sub Contracts	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
8 Bldg 105 Monitoring	0.1	3,241	1.5	0	0	0	0	100	0	0	100	0	0
9 Purge and Sample Groundwater Wells	0.6	12,963	6	0	0	0	0	100	0	100	0	0	0
10 Install Groundwater Pumps	0.1	2,161	1	0	0	0	0	100	0	70	30	0	0
Activity Total	2.0	64,358	21.5	4	11	0	0						
		64,358	100.0%	100.0%	100.0%			100.0%	5,401	33,060	15,094	0	10,803

Activity **02-05**

Building Maintanence

Activity Note

Activity Driver Candidates Footage, Bldg 8(AL & EA), Bldg 313 (AL & EA), Bldg 03 (AL), Bldg 216(EQ)

	FTE	Cost	People Time	Oper Supplies	Sub Contracts	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Write Work Orders	0.0	2,390	0.5	4.5	0	0	0		0	0	0	0	0
2 Maintanence Coordination	0.1	3,325	1	4	0	0	0		0	0	0	0	0
3 Install Equipment	0.0	1,663	0.5	2	0	0	0		0	0	0	0	0
4 Flourescent Bulbs/Asbestos Abatement/Lead Batteries	0.0	146	0	0.5	0	0	0	100	0	0	0	100	0
Activity Total	0.2	7,524	2	11	0	0	0						
		146	0.0%	4.5%				1.9%	0	0	0	146	0

Activity **02-06**

Manage the Department

Activity Note

Activity Driver Candidates None

	FTE	Cost	People Time	Oper Supplies	Sub Contracts	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Regulatory Training	0.1	2,161	1	0	0	0	0	100	100	0	0	0	0
2 Hold Safety Meetings	0.1	2,161	1	0	0	0	0		0	0	0	0	0
3 Plan, Prioritize, Budgets, Staff for Analytical Lab	0.2	5,401	2.5	0	0	0	0		0	0	0	0	0
4 Place People in Labs Where Needed	0.0	1,080	0.5	0	0	0	0		0	0	0	0	0
5 Manage Environmental Staffing	0.4	9,723	4.5	0	0	0	0		0	0	0	0	0
6 Safety Inspections	0.2	4,321	2	0	0	0	0		0	0	0	0	0
7 Help With Any Problems in Lab	0.1	3,241	1.5	0	0	0	0		0	0	0	0	0
8 All Production Samples	0.0	0	0	0	0	0	0		0	0	0	0	0
9 Oversee Platinum Inventory	0.0	1,371	0.5	1	0	0	0		0	0	0	0	0
10 Prepare Shift Report	0.0	1,080	0.5	0	0	0	0		0	0	0	0	0
11 Oversee Alcohol Inventory	0.0	1,080	0.5	0	0	0	0		0	0	0	0	0
12 Take Equipment to Shop for Repairs	0.0	1,371	0.5	1	0	0	0		0	0	0	0	0
13 Order Supplies and Equipment	0.1	3,241	1.5	0	0	0	0		0	0	0	0	0
14 Work w/ Production People to Keep Prod Samples Flowing	0.0	0	0	0	0	0	0		0	0	0	0	0
15 Attend OSAH Required Safety Meetings	0.0	1,080	0.5	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 02 Analytical Labs/Environmental Quality

16 Put Time in Computer from Previous Day	0.9	21,606	10	0	0	0	0		0	0	0	0	0
17 Issue Security Keys	0.0	1,080	0.5	0	0	0	0		0	0	0	0	0
Activity Total	2.5	59,998	27.5	2	0	0	0						
		2,161	3.6%	0.0%				3.6%	2,161	0	0	0	0

Activity **02-07**

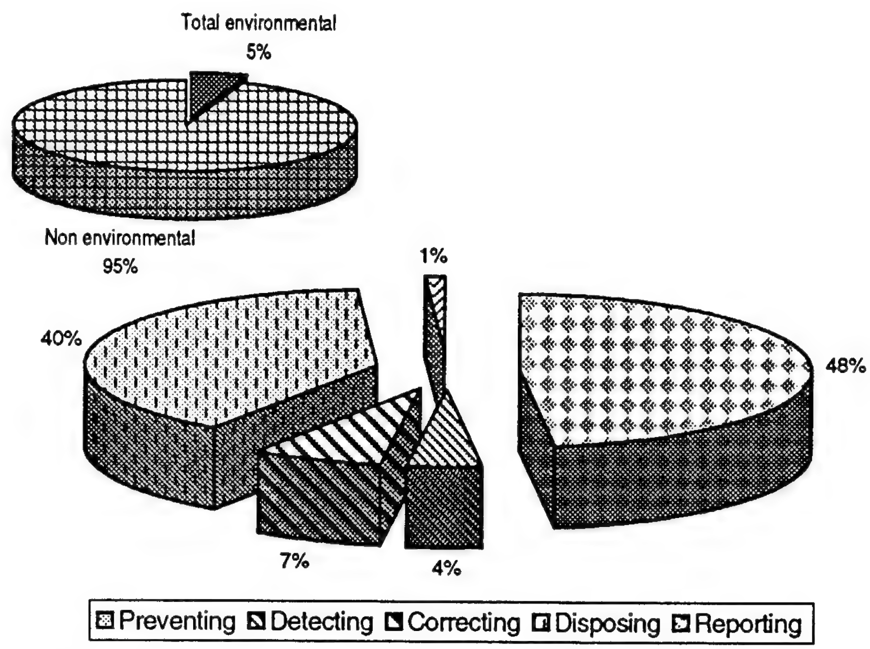
Test Production Samples

Activity Note

Activity Driver Candidates Batches, Products

	FTE	Cost	People Time	Oper Supplies	Sub Contracts	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Collect and Deliver Samples to Lab	0.3	6,482	3	0	0	0	0		0	0	0	0	0
2 Perform All Intermediate Testing	1.0	24,057	11	1	0	0	0		0	0	0	0	0
3 Explosives Waste Disposal	0.0	1,080	0.5	0	0	0	0	100	0	0	0	100	0
4 Sample, Drain and Maintain Dikes for Chemical Storage	0.0	1,080	0.5	0	0	0	0	100	100	0	0	0	0
5 Mercury Cleanup and Control	0.0	1,080	0.5	0	0	0	0	100	0	0	0	100	0
6 Perform All Finished Product Testing	1.5	34,860	16	1	0	0	0		0	0	0	0	0
7 Spectrosopy	0.6	13,255	6	1	0	0	0		0	0	0	0	0
8 Safety Testing	0.3	6,482	3	0	0	0	0		0	0	0	0	0
9 Chromotography	0.6	13,837	6	3	0	0	0		0	0	0	0	0
10 Compositions	1.6	38,392	17.5	2	0	0	0		0	0	0	0	0
11 Physical Attributes	0.8	19,445	9	0	0	0	0		0	0	0	0	0
12 Particle Size Characteristics	1.7	39,181	18	1	0	0	0		0	0	0	0	0
13 Catch Basin Analysis	0.2	4,321	2	0	0	0	0	100	0	0	0	100	0
Activity Total	8.6	203,553	93	9	0	0	0						
		7,562	3.8%	0.0%				3.7%	1,080	0	0	6,482	0
Session Total	22.0	558,460	239	40	20	0	0						
		176,591	27.8%	21.2%	100.0%				31,399	45,620	15,959	13,593	70,021

Explosives Manufacturing



Session Number	03		
Group	Explosives Manufacturing		
Organization	Production		

Category	Cost	% of Total	% of Environmental
Preventing	57,083	2.5%	48.0%
Detecting	5,121	0.2%	4.3%
Correcting	8,370	0.4%	7.0%
Disposing	47,005	2.1%	39.5%
Reporting	1,334	0.1%	1.1%
Total environmental	118,914	5.2%	100.0%
Non environmental	2,158,637	94.8%	
Cost	2,277,551	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
<u>03</u>	<u>Explosives Manufacturing</u>								
03-01	Making 581/521	1,731	0	0	346	0	2,077	96,130	2.2%
03-02	Receiving/Storage 581/521	5,528	0	0	0	0	5,528	81,687	6.8%
03-03	Analyzing 581,521, and 501/521	0	0	0	0	0	0	14,420	0.0%
03-04	Pumping from Bldg 151	3,364	0	0	0	0	3,364	33,638	10.0%
03-05	Manufacturing RDX/HMX	8,169	0	0	0	0	8,169	81,687	10.0%
03-06	Sampling	0	0	0	577	0	577	57,725	1.0%
03-07	Clean-up/Calibration	0	0	0	17,847	0	17,847	124,971	14.3%
03-08	Maintanence	3,605	0	0	3,605	0	7,210	14,420	50.0%
03-09	Processing Batch	0	0	0	0	0	0	129,789	0.0%
03-10	Recovering RDX/HDX	1,682	0	0	0	0	1,682	33,638	5.0%
03-11	Clean-up/Disposal	0	0	0	15,090	0	15,090	124,679	12.1%
03-12	Cleaning and Maintaining	0	0	0	1,374	0	1,374	92,458	1.5%
03-13	Solvent Receiving/Storage/Transferring	1,559	0	0	0	0	1,559	110,580	1.4%
03-14	Making Laquer	0	0	0	900	0	900	284,160	0.3%
03-15	Recrystallizing	0	0	0	2,452	0	2,452	355,776	0.7%
03-16	Coating	0	0	0	1,923	0	1,923	100,957	1.9%
03-17	Cleanup	0	0	0	1,557	0	1,557	69,569	2.2%
03-18	Receiving/Transferring	0	0	0	0	0	0	24,014	0.0%
03-19	Generic Activities	14,420	0	0	0	0	14,420	14,420	100.0%
03-20	Records	5,773	1,803	0	902	902	9,379	201,995	4.6%
03-21	Procedures	2,597	433	2,597	433	433	6,492	50,504	12.9%
03-22	Maintanence	8,657	0	5,773	0	0	14,429	108,208	13.3%
03-23	Managing	0	2,885	0	0	0	2,885	72,124	4.0%
Subtotal Explosives Manufacturing		57,083	5,121	8,370	47,005	1,334	118,914	2,277,551	5.2%

Holston Activity and Task Summary

Session 03 Explosives Manufacturing

Date	7/29/97	6 Participants	Larry Roberts, Grady Dockery, Hubert Drain, John File, Ben Hunter, Shelby Moore,	Observers	Alan, Glenn, Ennis, Keith, Mark
Time	8:00	FTE:	53 165 Years Experience	Note	Blue Dot: Labor Bright OrangeDot: Maintanence Orange Dot: Operating Supplies Green Dot: Environmental

Activity **03-01**

Making 581/521

Activity Note

Activity Driver Candidates Empty Tank

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
0 Header	0.0		0	3	0	0	0		0	0	0	0	0
1 Manufacture 581/521, Dissolve 501 in 521	0.8	34,619	2	0	0	0	0	5	5	0	0	0	0
2 501 Superstacks are Sent to Landfill when Empty	0.8	34,619	2	0	0	0	0	1	0	0	0	1	0
3 Re-Sample after Computer-Made Batch	0.4	26,892	1	2	0	0	0		0	0	0	0	0
Activity Total	2.0	96,130	5	5	0	0	0						
		2,077	2.4%	0.0%				2.2%	1,731	0	0	346	0

Activity **03-02**

Receiving/Storage 581/521

Activity Note

Activity Driver Candidates Inventory Levels

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
0 Header	0.0		0	2	0	0	0		0	0	0	0	0
1 Bld 151, 521 received in Railcars, 501 Received in Supersacks by Tractor Trailer	1.2	55,275	3	1	0	0	0	10	10	0	0	0	0
2 501 Superstacks unloaded by Bldg 151 Oprtrs & Stored Until Used Making 501/521	0.0	4,797	0	1	0	0	0		0	0	0	0	0
3 Pump 521 from Railcars to Storagetanks	0.4	21,616	1	1	0	0	0		0	0	0	0	0
Activity Total	1.6	81,687	4	5	0	0	0						
		5,528	7.5%	2.0%				6.8%	5,528	0	0	0	0

Activity **03-03**

Analyzing 581,521, and 501/521

Activity Note

Activity Driver Candidates Per Batch

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Sample 501 When Received. Sample Sent to Bldg 8	0.4	14,420	1	0	0	0	0		0	0	0	0	0

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
Activity Total	0.4	14,420	1	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity 03-04

Pumping from Bldg 151

Activity Note

Activity Driver Candidates Inventory

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
0 Header	0.0		0	1	0	0	0		0	0	0	0	0
1 501/521 is Pumped from Bldg 151 to D Bldg	0.4	16,819	1	0	0	0	0	10	10	0	0	0	0
3 521 Pumped from Bldg 151 or C-5 to D Bldg	0.4	16,819	1	0	0	0	0	10	10	0	0	0	0
Activity Total	0.8	33,638	2	1	0	0	0						
		3,364	10.0%	0.0%				10.0%	3,364	0	0	0	0

Activity 03-05

Manufacturing RDX/HMX

Activity Note

Activity Driver Candidates Batch

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
0 Header	0.0		0	5	0	0	0		0	0	0	0	0
1 Computer Control Addition Offeeds to Make RDX/HMX Control of Temp	0.4	20,416	1	0	0	0	0	10	10	0	0	0	0
2 Make RDX/HMX, AQE Batch, Add Water, Biomer, Cool, Pump to Recovery	0.8	40,855	2	0	0	0	0	10	10	0	0	0	0
3 Receive Chemical 509 and Chem 503-504	0.4	20,416	1	0	0	0	0	10	10	0	0	0	0
Activity Total	1.6	81,687	4	5	0	0	0						
		8,169	10.0%	0.0%				10.0%	8,169	0	0	0	0

Activity 03-06

Sampling

Activity Note

Activity Driver Candidates 5th Batch

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Sampling in each Production Bldg	0.8	28,863	2	0	0	0	0	1	0	0	0	1	0
2 D Bldg Yield Sample	0.8	28,863	2	0	0	0	0	1	0	0	0	1	0
Activity Total	1.6	57,725	4	0	0	0	0						
		577	1.0%					1.0%	0	0	0	577	0

Activity 03-07

Clean-up/Calibration

Activity Note

Activity Driver Candidates On Demand

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
0 Header	0.0		0	5	0	0	0		0	0	0	0	0
1 Routine Nitrator/Reaction Bailout	1.2	53,562	3	0	0	0	0		0	0	0	0	0
2 Clean Catch Basin Weekly	0.4	17,847	1	0	0	0	0	100	0	0	0	100	0
3 Constant Receipe & Calibration Checks	0.4	17,847	1	0	0	0	0		0	0	0	0	0
4 Computer Tech & Maintanence for Production	0.8	35,715	2	0	0	0	0		0	0	0	0	0
Activity Total	2.7	124,971	7	5	0	0	0						
		17,847	14.3%	0.0%				14.3%	0	0	0	17,847	0

Activity **03-08**

Maintanence

Activity Note

Activity Driver Candidates 180 Days

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Lock Out, Tag Out	0.4	14,420	1	0	0	0	0	50	25	0	0	25	0
Activity Total	0.4	14,420	1	0	0	0	0						
		7,210	50.0%					50.0%	3,605	0	0	3,605	0

Activity **03-09**

Processing Batch

Activity Note

Activity Driver Candidates 1 Batch

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
0 Header	0.0		0	4	0	0	0		0	0	0	0	0
2 E Bldg-Filter Acid from HDX/RDX, Wash w/ Water, Add Water, Pump to G Bldg	0.8	34,345	2	0	0	0	0		0	0	0	0	0
3 Receive Crude HMX/RDX from D Bldg & Wash w/ Water to Remove Acid	0.8	39,141	2	1	0	0	0		0	0	0	0	0
4 Wash HMX/RDX	1.2	56,303	3	1	0	0	0		0	0	0	0	0
5 Washed Slurry is Pumped from E Bldg to G Bldg After Sampling for % Acid	0.0		0	0	0	0	0	1	0	0	0	1	0
Activity Total	2.7	129,789	7	6	0	0	0						
		0	0.0%	0.0%				0.0%	0	0	0	0	0

Activity **03-10**

Recovering RDX/HDX

Activity Note

Activity Driver Candidates Inventory Level

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
0 Header	0.0		0	1	0	0	0		0	0	0	0	0
2 Recover HDX/RDX	0.4	16,819	1	0	0	0	0	10	10	0	0	0	0
3 Water from Washing Acid to Storage Tank, Settles, Pumped to B-Line Acid Area	0.0		0	0	0	0	0		0	0	0	0	0

4 Recycle Recovered from Storage Tank Washed and Pumped to G Bldg	0.4	16,819	1	0	0	0	0		0	0	0	0	0
Activity Total	0.8	33,638	2	1	0	0	0						
		1,682	5.0%	0.0%				5.0%	1,682	0	0	0	0

Activity **03-11**

Clean-up/Disposal

Activity Note

Activity Driver Candidates On Demand

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Samples Poured in Drain and Collected in Catch Basin	0.2	7,221	0.5	0	0	0	0		0	0	0	0	0
2 Catch Basin Material in Placed in Bags and Sent to Burning Ground	0.4	14,420	1	0	0	0	0	100	0	0	0	100	0
3 E Bldg Hot Water Wash	0.6	36,032	1.5	3	0	0	0		0	0	0	0	0
4 Changing Filter Cloth	0.0	67,006	0	6	100	0	0	1	0	0	0	1	0
Activity Total	1.2	124,679	3	9	100	0	0						
		15,090	33.3%	0.7%	1.0%			12.1%	0	0	0	15,090	0

Activity **03-12**

Cleaning and Maintaining

Activity Note

Activity Driver Candidates End of Run

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
0 Header	0.0		0	1	0	0	0		0	0	0	0	0
1 Clean Dissolvers at 150 w/ Solvents	0.8	40,375	2	2	0	0	0		0	0	0	0	0
3 Shop Repair all Breakdown and Work on Shutdown for 180 Days	0.4	15,380	1	0	0	0	0	1	0	0	0	1	0
4 Solvent Filters Cleaned as Needed	0.4	21,323	1	1	3	0	0	5	0	0	0	5	0
5 Solvents Used for Cleaning at 150 Transferred to G Bldg	0.4	15,380	1	0	0	0	0	1	0	0	0	1	0
Activity Total	2.0	92,458	5	4	3	0	0						
		1,374	1.4%	1.3%	5.0%			1.5%	0	0	0	1,374	0

Activity **03-13**

Solvent Receiving/Storage/Transferring

Activity Note

Activity Driver Candidates Inventory

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
0 Header	0.0		0	1	0	0	0		0	0	0	0	0
1 Schedule Receipt of Raw Materials and Solvents	0.4	15,106	1	0	0	0	0	5	5	0	0	0	0
2 Solvent Storage Tanks Nitrogen Purged (Constant Pressure)	0.4	15,106	1	0	0	0	0		0	0	0	0	0

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
3 Receive and Unload Solvents from Vendors	0.8	35,030	2	1	0	0	0	1	1	0	0	0	0
4 Pump Solutions to G Bldg	1.2	45,339	3	0	0	0	0	1	1	0	0	0	0
Activity Total	2.7	110,580	7	2	0	0	0						
		1,559	1.4%	0.5%				1.4%	1,559	0	0	0	0

Activity **03-14**

Making Laquer

Activity Note

Activity Driver Candidates 1 Batch

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
0 Header	0.0		0	2	0	0	0		0	0	0	0	0
1 Mix Binders w/ Solvents	0.8	29,873	2	0	0	0	0	1	0	0	0	1	0
2 Preparation of Binders	0.8	29,873	2	0	0	0	0		0	0	0	0	0
3 Pump in Solvent	1.2	44,798	3	0	0	0	0		0	0	0	0	0
4 Saw Binders	0.8	29,873	2	0	0	0	0		0	0	0	0	0
5 Grind Binders	0.8	29,873	2	0	0	0	0		0	0	0	0	0
6 Charging Binders	0.8	29,873	2	0	0	0	0		0	0	0	0	0
7 Drop Lacquer to Wagons	0.8	30,255	2	0	1	0	0	1	0	0	0	1	0
8 Transfer to G Bldg	0.8	29,873	2	0	0	0	0		0	0	0	0	0
9 Transfer Recovered Solvents from G Bldg	0.8	29,873	2	0	0	0	0	1	0	0	0	1	0
Activity Total	7.5	284,160	19	2	1	0	0						
		900	0.3%	0.0%	1.0%			0.3%	0	0	0	900	0

Activity **03-15**

Recrystallizing

Activity Note

Activity Driver Candidates 1 Batch

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Dissolve Crude HMX or RDX in Acetone or Cyclohoxanone	0.8	33,659	2	1	0	0	0	1	0	0	0	1	0
2 Cool Batches to Prevent Spills	0.8	28,863	2	0	0	0	0		0	0	0	0	0
3 Distill Solvent from Batches	4.7	192,298	12	4	0	0	0	1	0	0	0	1	0
4 Collect Decant Fines and Sample	0.4	19,217	1	1	0	0	0	1	0	0	0	1	0
5 Nutsche and Dewater	0.4	19,217	1	1	0	0	0		0	0	0	0	0
6 Water from Decant Goes to Settling Tank	0.8	28,863	2	0	0	0	0		0	0	0	0	0
7 Decant Water to Nutches and Pump Batch to H Bldg	0.8	33,659	2	1	0	0	0		0	0	0	0	0
Activity Total	8.6	355,776	22	8	0	0	0						
		2,452	0.7%	0.8%				0.7%	0	0	0	2,452	0

Holston Activity and Task Summary

Session 03 Explosives Manufacturing

Activity 03-16
Coating

Activity Note

Activity Driver Candidates Per Batch

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Mix Lacquers with RDX or HMX to produce PBX's	0.4	14,420	1	0	0	0	0	10	0	0	0	10	0
2 Distill Solvent	0.8	38,456	2	2	0	0	0		0	0	0	0	0
3 RDX, HMX, and PBX Batches Nutsched and Dewatered	1.2	48,080	3	1	0	0	0	1	0	0	0	1	0
Activity Total	2.4	100,957	6	3	0	0	0						
		1,923	2.2%	0.3%				1.9%	0	0	0	1,923	0

Activity 03-17
Cleanup

Activity Note

Activity Driver Candidates End of Run

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Boil Out with Water	0.4	19,217	1	1	0	0	0		0	0	0	0	0
2 Filter Bags Changed each Batch	0.4	15,567	1	0	3	0	0	5	0	0	0	5	0
3 Probe Socks Changed as Needed	0.4	15,567	1	0	3	0	0	5	0	0	0	5	0
4 Boil Out Still with Solvent- Acetone & Cyclohoxa	0.4	19,217	1	1	0	0	0		0	0	0	0	0
Activity Total	1.6	69,569	4	2	6	0	0						
		1,557	2.5%	0.0%	5.0%			2.2%	0	0	0	1,557	0

Activity 03-18
Receiving/Transferring

Activity Note

Activity Driver Candidates Batch

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Transfer Nutsched Material	0.4	24,014	1	2	0	0	0		0	0	0	0	0
Activity Total	0.4	24,014	1	2	0	0	0						
		0	0.0%	0.0%				0.0%	0	0	0	0	0

Activity 03-19
Generic Activities

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Extensive Classroom Session in Safety Programs	0.0		0	0	0	0	0	20	20	0	0	0	0
2 Cross-Training	0.0		0	0	0	0	0		0	0	0	0	0
3 Walk the Pipeline	0.4	14,420	1	0	0	0	0	100	100	0	0	0	0

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
Activity Total	0.4	14,420	1	0	0	0	0						
		14,420	100.0%					100.0%	14,420	0	0	0	0

Activity **03-20**

Records

Activity Note

Activity Driver Candidates Batch

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Explosives Record Keeping	1.0	36,062	2.5	0	0	0	0	5	0	0	0	2.5	2.5
2 Conduct Training	0.8	28,863	2	0	0	0	0	20	20	0	0	0	0
3 Inventory	1.0	36,062	2.5	0	0	0	0	5	0	5	0	0	0
4 Monitor SPC Systems	0.2	7,221	0.5	0	0	0	0		0	0	0	0	0
5 Production Planning	1.0	36,062	2.5	0	0	0	0		0	0	0	0	0
6 Schedule/Coordinate Operations	0.6	21,642	1.5	0	0	0	0		0	0	0	0	0
7 Monthly Quality Reports	0.2	7,221	0.5	0	0	0	0		0	0	0	0	0
8 Order Raw Materials	0.2	7,221	0.5	0	0	0	0		0	0	0	0	0
9 Production Status Reports	0.6	21,642	1.5	0	0	0	0		0	0	0	0	0
Activity Total	5.5	201,995	14	0	0	0	0						
		9,379	4.6%					4.6%	5,773	1,803	0	902	902

Activity **03-21**

Procedures

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Write PC's and MI's/SOP	0.6	21,642	1.5	0	0	0	0	10	2	2	2	2	2
2 FA Manual	0.2	7,221	0.5	0	0	0	0		0	0	0	0	0
3 PC/EC's/MDE's	0.6	21,642	1.5	0	0	0	0	20	10	0	10	0	0
Activity Total	1.4	50,504	3.5	0	0	0	0						
		6,492	12.9%					12.9%	2,597	433	2,597	433	433

Activity **03-22**

Maintanence

Activity Note

Activity Driver Candidates On Demand

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Coordinates Maintanence	1.2	43,283	3	0	0	0	0	20	20	0	0	0	0
2 Computer Program Maintanence	1.0	36,062	2.5	0	0	0	0		0	0	0	0	0
3 Production Troubleshooting	0.8	28,863	2	0	0	0	0	20	0	0	20	0	0
Activity Total	2.9	108,208	7.5	0	0	0	0						
		14,429	13.3%					13.3%	8,657	0	5,773	0	0

Holston Activity and Task Summary

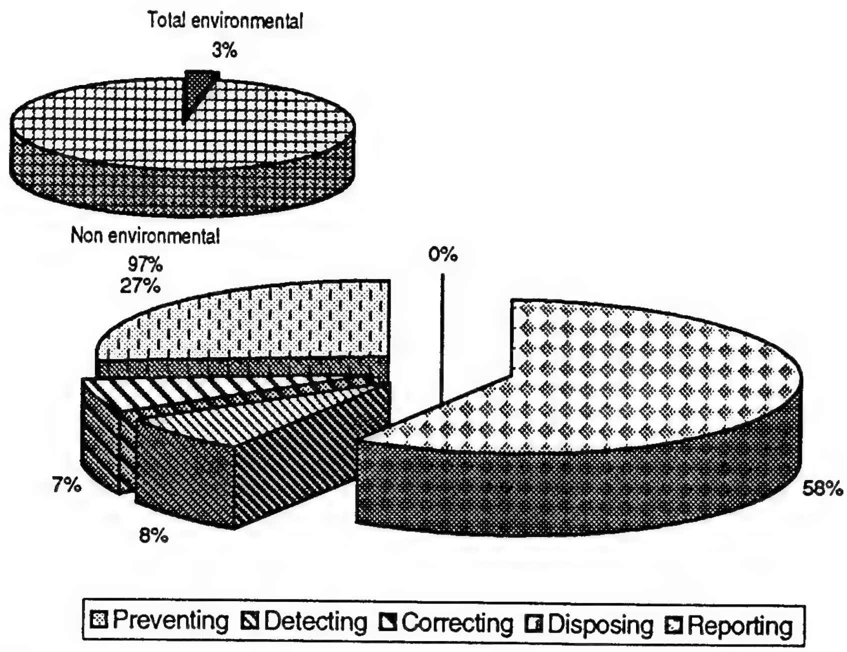
Session 03 Explosives Manufacturing

Activity **03-23**

Managing

	FTE	Cost	People Time	Maint enance	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
			Activity Note Activity Driver Candidates										
1 Monitor Operations	1.6	57,704	4	0	0	0	0	5	0	5	0	0	0
2 Enter Record of Operator Time	0.4	14,420	1	0	0	0	0		0	0	0	0	0
Activity Total	2.0	72,124	5	0	0	0	0						
		2,885	4.0%					4.0%	0	2,885	0	0	0
Session Total	53.0	2,277,551	135	60	110	0	0						
		118,914	5.6%	0.5%	1.3%				57,083	5,121	8,370	47,005	1,334

Explosives Finishing/Materials Handling



Session Number	04
Group	Explosives Finishing/Materials Handling
Organization	Production

Category	Cost	% of Total	% of Environmental
Preventing	33,047	1.8%	58.9%
Detecting	4,374	0.2%	7.8%
Correcting	3,828	0.2%	6.8%
Disposing	14,873	0.8%	26.5%
Reporting	-	0.0%	0.0%
Total environmental	56,122	3.0%	100.0%
Non environmental	1,812,897	97.0%	
Cost	1,869,018	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
04	Explosives Finishing/Materials Handling								
04-01	Cleaning Operating Bldgs and Equipment	0	0	0	10,936	0	10,936	123,416	8.9%
04-02	Servicing Customers	0	0	0	0	0	0	18,148	0.0%
04-03	Shipping Explosives	0	0	0	0	0	0	27,104	0.0%
04-04	Supporting Production Operations	18,810	0	0	0	0	18,810	187,457	10.0%
04-05	Improving Projects	6,015	1,640	3,828	3,828	0	15,310	98,424	15.6%
04-06	Recording Batch Data	0	0	0	109	0	109	76,552	0.1%
04-07	Safety Audits	0	0	0	0	0	0	20,307	0.0%
04-08	Handling Materials	0	1,640	0	0	0	1,640	165,783	1.0%
04-09	Storing Materials Long/Short Term	0	1,094	0	0	0	1,094	131,231	0.8%
04-10	Packaging	5,246	0	0	0	0	5,246	97,716	5.4%
04-11	Retag C4	1,062	0	0	0	0	1,062	215,768	0.5%
04-12	Incorporation	797	0	0	0	0	797	47,647	1.7%
04-13	Blending	0	0	0	0	0	0	76,552	0.0%
04-14	Drying	1,117	0	0	0	0	1,117	111,698	1.0%
04-15	Receiving and Dewatering	0	0	0	0	0	0	471,216	0.0%
Subtotal Explosives Finishing/Materials Handli		33,047	4,374	3,828	14,873	0	56,122	1,869,018	3.0%

Holston Activity and Task Summary

Session 04 Explosives Finishing/Materials Handling

Date	7/29/97	4 Participants	Jeff Myers, Charles Richmond, Bob Hensley, Harron Gilliam	Observers	Alan, Ennis, Glenn, Keith
Time	1:00	FTE:	51 75 Years Experience	Note	Blue Dot: Labor Bright OrangeDot: Operating Supplies Orange Dot: Maintanence Green Dot: Environmental

Activity **04-01**

Cleaning Operating Bldgs and Equipm

Activity Note

Activity Driver Candidates Bldg/Process

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Solvent Cleanings	0.0	0	0	0	0	0	0		0	0	0	0	0
2 Clean Nutsches	0.3	24,992	1	0	1.5	0	0		0	0	0	0	0
3 Clean Water	1.0	32,808	3	0	0	0	0		0	0	0	0	0
4 Clean Steam	0.3	10,936	1	0	0	0	0		0	0	0	0	0
5 Cleaning Scrubbers	0.3	10,936	1	0	0	0	0		0	0	0	0	0
6 Clean-up of Bldg	0.7	21,872	2	0	0	0	0		0	0	0	0	0
7 Cleaning of Catch Basins/ Settling Tanks	0.3	10,936	1	0	0	0	0	100	0	0	0	100	0
8 Relocating Material to Burning Ground for Disposal	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
9 Clean Use Power Washer	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
Activity Total	3.4	123,416	10	0	1.5	0	0						
		10,936	10.0%		0.0%			8.9%	0	0	0	10,936	0

Activity **04-02**

Activity Note Envronmental Benefit:
Sale of Substandard Explosives
By-product Disposal

Servicing Customers

Activity Driver Candidates Product/Order

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Sales of Substandard Explosives	0.2	7,212	0.5	1	0	0	0		0	0	0	0	0
2 By-Product Disposal	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
3 Customer Complaints	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.5	18,148	1.5	1	0	0	0						
		0	0.0%	0.0%				0.0%	0	0	0	0	0

Activity **04-03**

Shipping Explosives

Activity Note

Activity Driver Candidates Batch/Lot

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing

Holston Activity and Task Summary

Session 04 Explosives Finishing/Materials Handling

Task	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Contact Between Board of Explosives and Holston Def. Comp.	0.0	0	0	0	0	0	0		0	0	0	0	0
2 Ship Explosives	0.7	27,104	2	3	0	0	0		0	0	0	0	0
3 Government Approval of Shipping Documents	0.0	0	0	0	0	0	0		0	0	0	0	0
4 Shipping Papers	0.0	0	0	0	0	0	0		0	0	0	0	0
5 Create Bills of Lading	0.0	0	0	0	0	0	0		0	0	0	0	0
6 Safety Approval of all Receiving and Shipping Explosives	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.7	27,104	2	3	0	0	0						
		0	0.0%	0.0%				0.0%	0	0	0	0	0

Activity 04-04

Supporting Production Operations

Activity Note

Activity Driver Candidates Batch

Task	*FTE*	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Managers Dept.	0.5	16,404	1.5	0	0	0	0		0	0	0	0	0
2 Staffing	0.0	0	0	0	0	0	0		0	0	0	0	0
3 Maintanence of Operations	0.0	0	0	0	0	0	0		0	0	0	0	0
4 Contact Between Lab and Production	0.3	10,936	1	0	0	0	0		0	0	0	0	0
5 Training	1.0	32,808	3	0	0	0	0	40	40	0	0	0	0
6 Department Safety Coodinator	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
7 Order Supplies	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
8 Training Record Keeping	0.7	21,872	2	0	0	0	0	1	1	0	0	0	0
9 Schedule Personnel	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
10 Dept. Environmental Coordinator	0.2	5,468	0.5	0	0	0	0	100	100	0	0	0	0
11 Production Reports	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
12 180 day PM	0.2	33,581	0.5	0	3	0	0		0	0	0	0	0
13 Safety Audits	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
14 Check on all Production Line Personnel	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
15 Schedule Maintanence	0.2	33,581	0.5	0	3	0	0		0	0	0	0	0
Activity Total	4.1	187,457	12	0	6	0	0						
		18,810	14.3%		0.0%			10.0%	18,810	0	0	0	0

Activity 04-05

Improving Projects

Activity Note

Activity Driver Candidates Process/Product

Task	*FTE*	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 MOE's (Memo of Explosives)	0.3	10,936	1	0	0	0	0	10	10	0	0	0	0
2 VE's (Value Engineering)	0.3	10,936	1	0	0	0	0	10	10	0	0	0	0

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
3 PC's/EC's (Procurment Change/Equipment Change)	1.0	32,808	3	0	0	0	0	20	5	5	5	5	0
4 PECI Projects(Process Evaluation Control Improvement)	0.7	21,872	2	0	0	0	0	20	6.67	0	6.67	6.67	0
5 SOP/MI Updates (MI=Manufacturing Instructions)	0.7	21,872	2	0	0	0	0	10	3.33	0	3.33	3.33	0
6 Oversee Projects	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	3.1	98,424	9	0	0	0	0						
		15,310	15.6%					15.6%	6,015	1,640	3,828	3,828	0

Activity **04-06**

Recording Batch Data

Activity Note

Activity Driver Candidates Batch

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 SPC (Stat Proc Cont)	0.7	21,872	2	0	0	0	0		0	0	0	0	0
2 Keep Records	0.3	10,936	1	0	0	0	0	1	0	0	0	1	0
3 Schedule Production	0.3	10,936	1	0	0	0	0		0	0	0	0	0
4 Generate (Computer) Labels, Charts, Flow Sheets, etc.	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
5 Receiving Lab Data	0.5	16,404	1.5	0	0	0	0		0	0	0	0	0
6 Production Reporting	0.3	10,936	1	0	0	0	0		0	0	0	0	0
Activity Total	2.4	76,552	7	0	0	0	0						
		109	0.1%					0.1%	0	0	0	109	0

Activity **04-07**

Safety Audits

Activity Note

Activity Driver Candidates Bldg

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Laddor Safety Inspections	0.2	14,839	0.5	0	1	0	0		0	0	0	0	0
2 Bldg Safety Audits	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.3	20,307	1	0	1	0	0						
		0	0.0%		0.0%			0.0%	0	0	0	0	0

Activity **04-08**

Handling Materials

Activity Note

Activity Driver Candidates Batch

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Allocations	1.7	54,680	5	0	0	0	0		0	0	0	0	0
2 Lableling Boxes	0.2	7,212	0.5	1	0	0	0		0	0	0	0	0
3 Receiving Supplies	1.0	32,808	3	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 04 Explosives Finishing/Materials Handling

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
4 Distribtution of Supplies	1.2	38,276	3.5	0	0	0	0		0	0	0	0	0
5 Inventory	1.0	32,808	3	0	0	0	0	5	0	5	0	0	0
Activity Total	5.1	165,783	15	1	0	0	0						
		1,640	1.0%	0.0%				1.0%	0	1,640	0	0	0

Activity **04-09**

Storing Materials Long/Short Term

Activity Note

Activity Driver Candidates Batch

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Storage of Material in the Magazine Area	0.7	21,872	2	0	0	0	0	5	0	5	0	0	0
2 Inventory	2.0	65,616	6	0	0	0	0		0	0	0	0	0
3 Lag Storage	1.0	32,808	3	0	0	0	0		0	0	0	0	0
4 Trailer Storage	0.3	10,936	1	0	0	0	0		0	0	0	0	0
Activity Total	4.1	131,231	12	0	0	0	0						
		1,094	0.8%					0.8%	0	1,094	0	0	0

Activity **04-10**

Packaging

Activity Note

Activity Driver Candidates Batch/lot

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Boxing Material	0.7	28,848	2	4	0	0	0		0	0	0	0	0
2 Bagging Explosives	0.5	16,404	1.5	0	0	0	0		0	0	0	0	0
3 Drumming of Explosives	1.4	52,464	4	5	0	0	0	10	10	0	0	0	0
Activity Total	2.5	97,716	7.5	9	0	0	0						
		5,246	5.3%	5.6%				5.4%	5,246	0	0	0	0

Activity **04-11**

Retag C4

Activity Note

Activity Driver Candidates Batch

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Tagging C4	2.7	106,230	8	0	2	0	0	1	1	0	0	0	0
2 Sample Batches	1.0	34,552	3	1	0	0	0		0	0	0	0	0
3 Break-up Material	1.0	32,808	3	0	0	0	0		0	0	0	0	0
4 Transferring Material Bldg & Bldg's	1.0	42,179	3	0	1	0	0		0	0	0	0	0
Activity Total	5.8	215,768	17	1	3	0	0						
		1,062	0.5%	0.0%	0.7%			0.5%	1,062	0	0	0	0

Holston Activity and Task Summary

Session 04 Explosives Finishing/Materials Handling

Activity 04-12

Incorporation

Activity Note

Activity Driver Candidates Batch

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Incorporation of Castables	0.2	14,839	0.5	0	1	0	0	5	5	0	0	0	0
2 Inspection of TNT	0.2	5,468	0.5	0	0	0	0	1	1	0	0	0	0
3 Rework Material	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
4 Chek for Repairs	0.7	21,872	2	0	0	0	0		0	0	0	0	0
Activity Total	1.2	47,647	3.5	0	1	0	0						
		797	0.9%		5.0%			1.7%	797	0	0	0	0

Activity 04-13

Blending

Activity Note

Activity Driver Candidates Batch

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Blending Material	0.3	10,936	1	0	0	0	0		0	0	0	0	0
2 Rework Material	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
3 Hand Blend	0.2	5,468	0.5	0	0	0	0		0	0	0	0	0
4 Shovel Blend	1.7	54,680	5	0	0	0	0		0	0	0	0	0
Activity Total	2.4	76,552	7	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity 04-14

Drying

Activity Note

Activity Driver Candidates Batch

	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Kettle Drying Materials	0.7	31,243	2	0	1	0	0	1	1	0	0	0	0
2 Tray Drying	0.7	21,872	2	0	0	0	0	1	1	0	0	0	0
3 Sample Batch	1.0	32,808	3	0	0	0	0	1	1	0	0	0	0
4 Rework Material	0.2	5,468	0.5	0	0	0	0	1	1	0	0	0	0
5 Bed Drying	0.3	20,307	1	0	1	0	0	1	1	0	0	0	0
Activity Total	2.9	111,698	8.5	0	2	0	0						
		1,117	1.0%		1.0%			1.0%	1,117	0	0	0	0

Activity 04-15

Receiving and Dewatering

Activity Note Environmental Benefit: Dewater Batch

Activity Driver Candidates Batch

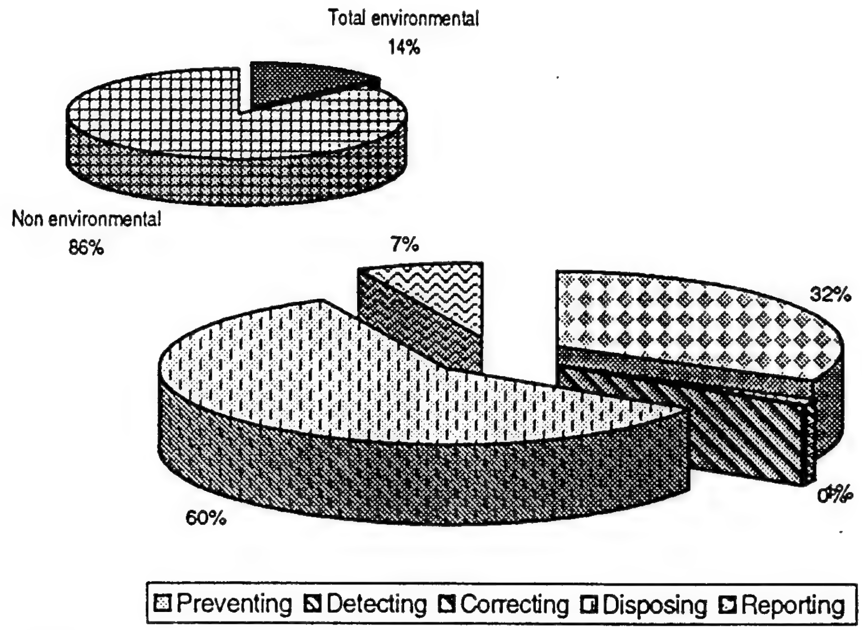
	FTE	Cost	People Time	Oper Supplies	Maint enance	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Grinding of Material	0.3	20,307	1	0	1	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 04 Explosives Finishing/Materials Handling

2 Change Charts	0.2	22,908	0.5	10	0	0	0		0	0	0	0	0
3 Start Paperwork	0.3	10,936	1	0	0	0	0		0	0	0	0	0
4 Get Batch of Material in Bldg	0.5	16,404	1.5	0	0	0	0		0	0	0	0	0
5 Charging	0.3	10,936	1	0	0	0	0		0	0	0	0	0
6 SWECO Batch	– 2.0	74,987	6	0	1	0	0		0	0	0	0	0
7 Drop Batch	2.4	76,552	7	0	0	0	0		0	0	0	0	0
8 Dewater Batch	1.4	47,232	4	2	0	0	0		0	0	0	0	0
9 Pull and Weigh-up Batch	0.7	28,301	2	1	0.5	0	0		0	0	0	0	0
10 Transport Batch	3.7	139,037	11	0	2	0	0		0	0	0	0	0
11 Sampling	0.7	23,616	2	1	0	0	0		0	0	0	0	0
Activity Total	12.6	471,216	37	14	4.5	0	0						
		0	0.0%	0.0%	0.0%			0.0%	0	0	0	0	0
Session Total	51.0	1,869,018	150	29	19	0	0						
		56,122	3.3%	1.7%	0.5%				33,047	4,374	3,828	14,873	0

Utilities, Area B Steam



Session Number	05
Group	Utilities, Area B Steam
Organization	Production Support

Category	Cost	% of Total	% of Environmental
Preventing	31,255	4.5%	32.2%
Detecting	1,003	0.1%	1.0%
Correcting	439	0.1%	0.5%
Disposing	57,247	8.2%	59.0%
Reporting	7,031	1.0%	7.2%
Total environmental	96,976	13.8%	100.0%
Non environmental	604,853	86.2%	
Cost	701,829	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
05	Utilities, Area B Steam								
05-01	Dispose of Waste	5,012	0	0	56,297	7,031	68,340	96,775	70.6%
05-02	Make Steam	22,901	1,003	439	299	0	24,643	274,404	9.0%
05-03	Treat Water	0	0	0	615	0	615	49,241	1.2%
05-04	Receive Coal	2,991	0	0	0	0	2,991	147,748	2.0%
05-05	Make Air	281	0	0	0	0	281	63,328	0.4%
05-06	Manage Operations	70	0	0	35	0	105	70,333	0.1%
Subtotal Utilities, Area B Steam		31,255	1,003	439	57,247	7,031	96,976	701,829	13.8%

Holston Activity and Task Summary

Session 05 Utilities, Area B Steam

Date	7/30/97	5 Participants	George Davenport, Rusty Hensley, Ina Peters, Debbie Roberts, James Stewart	Observers	Alan, Ennis, Glenn. Keith, Mark
Time	8:00	FTE:	16 121 Years Experience	Note	Task Numbers 1-40 are from Area A; Task Numbers 40+ are from Area B

Activity **05-01**

Dispose of Waste

Activity Note

Activity Driver Candidates Steam Usage

Task	FTE	Cost	People Time	Maintena nce	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
41 Blow Soot	0.4	29,932	3.5	2	0	0	0	5	5	0	0	0	0
42 Pump Water Out and Run PH Sample	0.1	3,515	1	0	0	0	0	100	100	0	0	0	0
43 Run Fly Ash Equipment	0.5	35,205	5	2	0	0	0	100	0	0	0	100	0
44 Measure Flyash	0.2	7,031	2	0	0	0	0	100	0	0	0	0	100
45 Load Out Cinder	0.2	7,031	2	0	0	0	0	100	0	0	0	100	0
46 Load Out Fly Ash	0.4	14,061	4	0	0	0	0	100	0	0	0	100	0
Activity Total	1.9	96,775	17.5	4	0	0	0						
		68,340	81.0%	52.5%				70.6%	5,012	0	0	56,297	7,031

Activity **05-02**

Make Steam

Activity Note

Activity Driver Candidates Steam Usage

Task	FTE	Cost	People Time	Maintena nce	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
41 Check Oil Level and Oil Rings on Feedback Pumps	0.4	14,061	4	0	0	0	0	2	0	1	0	1	0
42 Check Pump Pressure on Feed Water Pump	0.3	28,174	3	2	0	0	0		0	0	0	0	0
43 Turn Alarms Off	0.2	14,087	1.5	1	0	0	0	5	0	5	0	0	0
44 Adjust Air Flows as Load on Boilers Changes	0.8	26,365	7.5	0	0	0	0		0	0	0	0	0
45 Check Fly Ash Inspection Line	0.3	17,603	2.5	1	0	0	0		0	0	0	0	0
46 Sweep Floors, Clean Boilers, Empty Dust Pans	0.4	12,304	3.5	0	0	0	0		0	0	0	0	0
47 Grease Stokers	0.1	12,329	1	1	0	0	0		0	0	0	0	0
48 Restart Stokers, Grates, Flyash Induce Fans, Precipitators After Power Failures	0.3	8,788	2.5	0	0	0	0	5	0	0	5	0	0
49 Chck Other Oper About Operations	0.1	3,515	1	0	0	0	0		0	0	0	0	0
50 Check w/ Other Operators for Excessive Steam or Air Usage	0.2	5,273	1.5	0	0	0	0		0	0	0	0	0
51 Check Precipitator Vent Fans	0.1	3,515	1	0	0	0	0		0	0	0	0	0
52 Check Feed Water Temp	0.2	5,273	1.5	0	0	0	0		0	0	0	0	0
53 Check Log Book Basement and Operating Floors	0.2	7,031	2	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 05 Utilities, Area B Steam

	FTE	Cost	People Time	Maintenance	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
54 Check Rappers	0.2	22,901	1.5	2	0	0	0	100	100	0	0	0	0
55 Check Oil Levels in Grate Drives	0.2	15,845	2	1	0	0	0	2	0	1	0	1	0
56 Log Operations	0.6	19,335	5.5	0	0	0	0		0	0	0	0	0
57 Check Fire Bed for Low and High Spots	0.6	21,092	6	0	0	0	0		0	0	0	0	0
58 Maintain L.P. Steam Station	0.3	8,788	2.5	0	0	0	0		0	0	0	0	0
59 Check Steam Comp. Rate	0.3	10,546	3	0	0	0	0		0	0	0	0	0
60 Check Boiler Load on Operating Boiler	0.3	10,546	3	0	0	0	0		0	0	0	0	0
61 Grease Coal Equipment	0.1	3,515	1	0	0	0	0		0	0	0	0	0
62 Run Emergency Generator	0.1	3,515	1	0	0	0	0		0	0	0	0	0
Activity Total	6.2	274,404	58	8	0	0	0						
		24,643	3.1%	25.9%				9.0%	22,901	1,003	439	299	0

Activity **05-03**

Treat Water

				Activity Note									
				Activity Driver Candidates				Steam Usage					
	FTE	Cost	People Time	Maintenance	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
41 Run Water Samples	0.2	15,845	2	1	0	0	0	1	0	0	0	1	0
42 Generate Water Sample	0.1	3,515	1	0	0	0	0	5	0	0	0	5	0
43 Mix Chemicals	0.1	1,758	0.5	0	0	0	0		0	0	0	0	0
44 Check Equipment	0.1	3,515	1	0	0	0	0		0	0	0	0	0
45 Check DA Heater	0.1	3,515	1	0	0	0	0		0	0	0	0	0
46 Blow Down Boiler Water Columns	0.4	14,061	4	0	0	0	0	1	0	0	0	1	0
47 Adjust Water Blow Downs	0.2	7,031	2	0	0	0	0	2	0	0	0	2	0
Activity Total	1.2	49,241	11.5	1	0	0	0						
		615	1.3%	1.0%				1.2%	0	0	0	615	0

Activity **05-04**

Receive Coal

				Activity Note									
				Activity Driver Candidates				Steam Usage					
	FTE	Cost	People Time	Maintenance	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
41 Pull Coal Car Over Pit and Open Doors on Cars	0.1	3,515	1	0	0	0	0		0	0	0	0	0
42 Take to Railroad About Coal Delivery	0.1	3,515	1	0	0	0	0		0	0	0	0	0
43 Operate Loader	0.2	7,031	2	0	0	0	0		0	0	0	0	0
44 Unload Coal	1.3	59,813	12	2	0	0	0	5	5	0	0	0	0
45 Do Bunker Room Clean-up	1.1	35,154	10	0	0	0	0		0	0	0	0	0
46 Take Sample of Coal and Send Samples to Bldg 235 for Analysis	0.0	0	0	0	0	0	0		0	0	0	0	0
47 Sweep and Clean Assigned Areas Fire Floors, etc.	0.2	7,031	2	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 05 Utilities, Area B Steam

48 Take Air Off Coal Cars(Braking System) as well as Hand Brakes	0.0	0	0	0	0	0	0		0	0	0	0	0
49 Check Coal Handling Equipment Bldg 238 to 239 to 4th Floor Bunker	0.4	31,690	4	2	0	0	0		0	0	0	0	0
Activity Total	3.4	147,748	32	4	0	0	0						
		2,991	1.9%	2.5%				2.0%	2,991	0	0	0	0

Activity **05-05**

Make Air

			Activity Note										
			Activity Driver Candidates				Steam Usage						
	FTE	Cost	People Time	Maintenance	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
41 Grease Equipment in Compressor Bldg	0.2	15,845	2	1	0	0	0		0	0	0	0	0
42 Check and Log Compressor Bldg Equipment	0.9	28,123	8	0	0	0	0	1	1	0	0	0	0
43 Go to Compressor Bldg and Turn Compressors on in Case of Power Outages	0.1	3,515	1	0	0	0	0		0	0	0	0	0
44 Run Outisde Portable Compressors	0.2	15,845	2	1	0	0	0		0	0	0	0	0
Activity Total	1.4	63,328	13	2	0	0	0						
		281	0.6%	0.0%				0.4%	281	0	0	0	0

Activity **05-06**

Manage Operations

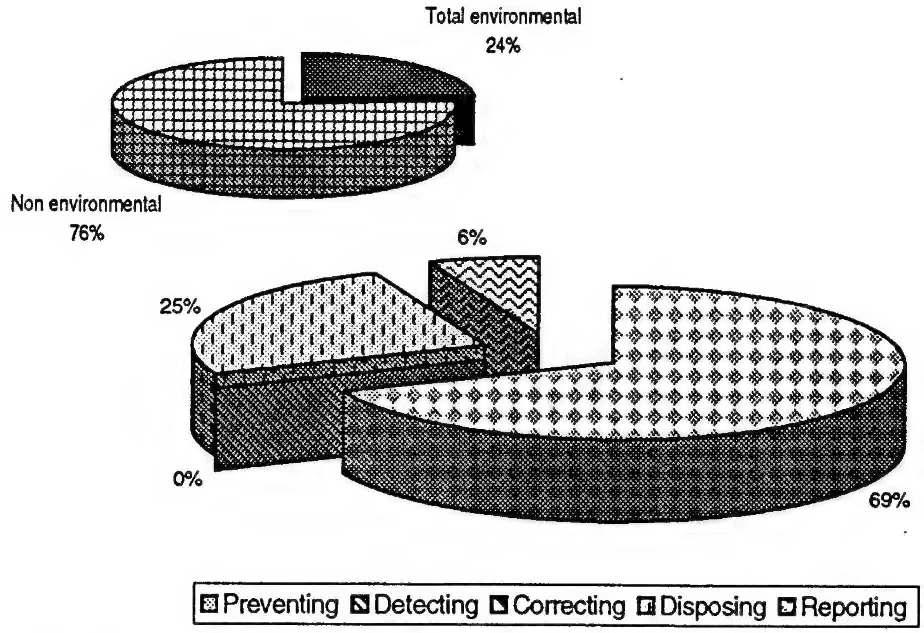
			Activity Note										
			Activity Driver Candidates				Steam Usage						
	FTE	Cost	People Time	Maintenance	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
41 Keep Time Sheets	0.3	8,788	2.5	0	0	0	0		0	0	0	0	0
42 Do Lock-Out and Tag-Out for Maintanence	0.1	3,515	1	0	0	0	0	1	0	0	0	0	0
43 Refer Steam Leaks to Maintanence	0.1	12,329	1	1	0	0	0		0	0	0	1	0
44 Environment Compliance Training	0.0	0	0	0	0	0	0	100	50	0	0	0	50
45 Check w/ Maintanence Personnel on Jobs to be Done Today	0.1	3,515	1	0	0	0	0		0	0	0	0	0
46 Inventory Chemicals	0.0	0	0	0	0	0	0	100	100	0	0	0	0
47 Take Call from Maintanence	0.1	3,515	1	0	0	0	0		0	0	0	0	0
48 Check w/ Steam Power Operator on Daily Operation	0.1	3,515	1	0	0	0	0		0	0	0	0	0
49 Call in Maintanence in Case of Emergency	0.0	0	0	0	0	0	0		0	0	0	0	0
50 Write Work Orders	0.1	3,515	1	0	0	0	0	2	2	0	0	0	0
51 Attend, Hold, Lead Safety Meetings	0.3	10,546	3	0	0	0	0		0	0	0	0	0
52 Order Grease and Oil	0.0	0	0	0	0	0	0		0	0	0	0	0
53 Fill Pool Vehicle with Gas	0.2	7,031	2	0	0	0	0		0	0	0	0	0
54 Do Safety Permit for All Job, Electric, Mechanic, Instrument	0.2	7,031	2	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 05 Utilities, Area B Steam

55 Go to Storerom for Needed Itmes	0.1	3,515	1	0	0	0	0		0	0	0	0	0
56 Check Leak to Steam Line for Severity of Leak, Does it Need Cut-Out (nights)	0.1	3,515	1	0	0	0	0		0	0	0	0	0
Activity Total	1.9	70,333	17.5	1	0	0	0						
		105	0.2%	0.0%				0.1%	70	0	0	35	0
Session Total	16.0	701,829	149.5	20	0	0	0						
		96,976	11.3%	21.4%					31,255	1,003	439	57,247	7,031

Organic Acids



Session Number	06
Group	Organic Acids
Organization	Production Support

Category	Cost	% of Total	% of Environmental
Preventing	162,826	16.3%	68.6%
Detecting	-	0.0%	0.0%
Correcting	-	0.0%	0.0%
Disposing	60,076	6.0%	25.3%
Reporting	14,384	1.4%	6.1%
Total environmental	237,286	23.7%	100.0%
Non environmental	763,464	76.3%	
Cost	1,000,751	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
<u>06</u>	<u>Organic Acids</u>								
06-01	Receiving Materials	6,630	0	0	0	0	6,630	34,443	19.2%
06-02	Operate Process	103,052	0	0	48,133	0	151,186	608,675	24.8%
06-03	Control Process	19,066	0	0	11,943	0	31,008	143,337	21.6%
06-04	Deliver Product	7,203	0	0	0	0	7,203	28,810	25.0%
06-05	Conduct Training	9,003	0	0	0	1,801	10,804	45,016	24.0%
06-06	Manage Operations	17,873	0	0	0	12,583	30,456	140,470	21.7%
Subtotal Organic Acids		162,826	0	0	60,076	14,384	237,286	1,000,751	23.7%

Holston Activity and Task Summary

Session 06 Organic Acids

Date 7/30/97 4 Participants Ernie Botts, Carolyn McNutt, Robert Salyer, Tommy Williams Observers Alan, Ennis, Glenn. Keith

Time 1:00 pm FTE: 27 112 Years Experience Note

Activity **06-01**

Receiving Materials

Activity Note

Activity Driver Candidates Volume of acid product

	FTE	Cost	People Time	Maintenance	Oper Supplies	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Receive Catalyst	0.1	9,235	0.5	1	0	0	0	25	25	0	0	0	0
2 Order Chemicals - Tri-ethyl & Npropyl	0.1	3,601	1	0	0	0	0		0	0	0	0	0
3 Receive 525 from Area B	0.5	14,405	4	0	0	0	0	25	25	0	0	0	0
4 Receive Ammonia	0.1	1,801	0.5	0	0	0	0	15	15	0	0	0	0
5 Receive Car to load from Area B	0.0	0	0	0	0	0	0		0	0	0	0	0
6 receive Solvent (N-Propyl Acetate)	0.1	1,801	0.5	0	0	0	0	25	25	0	0	0	0
7 Receive Nitrogen	0.1	3,601	1	0	0	0	0		0	0	0	0	0
Activity Total	0.9	34,443	7.5	1	0	0	0						
		6,630	' 17.7%	25.0%				19.2%	6,630	0	0	0	0

Activity **06-02**

Operate Process

Activity Note

Activity Driver Candidates Volume of Acid Product

	FTE	Cost	People Time	Maintenance	Oper Supplies	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Concentrate Acetic Acid from 55% to 99.7% in azrotropic distillation	3.9	156,011	33	5	0	0	0	20	10	0	0	10	0
2 Convert glacial acetic acid to crude acetic anhydride via catalytic cracking	4.5	196,320	38	8	0	0	0	20	10	0	0	10	0
3 Check with tank farm operator	0.4	15,703	3.5	0	1	0	0		0	0	0	0	0
4 Refine crude acetic anhysdride from 84% to 98% via distillation	2.1	101,993	18	5	0	0	0	20	10	0	0	10	0
7 Check dikes for leaks	0.7	21,608	6	0	0	0	0	100	100	0	0	0	0
8 Everyone in dept uses radios	0.2	7,203	2	0	0	0	0		0	0	0	0	0
9 Sludge back to waste water pond	0.0	0	0	0	0	0	0	100	0	0	0	100	0
10 Make process improvements/Troubleshoot	0.1	3,601	1	0	0	0	0	25	25	0	0	0	0
11 Tank farm operator inspects tanks	0.4	10,804	3	0	0	0	0		0	0	0	0	0
12 Everyone inspects piping	0.6	18,006	5	0	0	0	0	100	100	0	0	0	0
13 Check all feeds and flows on stills and furnaces	0.7	19,807	5.5	0	0	0	0		0	0	0	0	0
14 Perform safety inspections	0.7	21,608	6	0	0	0	0		0	0	0	0	0
15 Check with maintenance forman for work to be done	0.7	21,608	6	0	0	0	0	25	12.5	0	0	12.5	0
16 Check PH Meters	0.5	14,405	4	0	0	0	0	100	100	0	0	0	0

	FTE	Cost	People Time	Maintenance	Oper Supplies	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
17 Clean Solvent	0.0	0	0	0	0	0	0	100	0	0	0	100	0
Activity Total	15.5	608,675	131	18	1	0	0						
		151,186	26.4%	20.0%	0.0%			24.8%	103,052	0	0	48,133	0

Activity **06-03**

Control Process

Activity Note

Activity Driver Candidates Time

	FTE	Cost	People Time	Maintena nce	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Operator does sampling on product	1.8	69,511	15	0	5	0	0	20	8	0	0	12	0
2 Enter sample data into computer	0.5	14,405	4	0	0	0	0		0	0	0	0	0
3 Run freeze points	0.2	7,203	2	0	0	0	0		0	0	0	0	0
4 Test product at titration table	0.5	14,405	4	0	0	0	0		0	0	0	0	0
5 Coordinate operations w/utilities dept	0.4	12,604	3.5	0	0	0	0	50	50	0	0	0	0
6 Vent all vapor in scrubber at Tf #27	0.2	7,203	2	0	0	0	0	100	50	0	0	50	0
7 Check all tanks at TF#27	0.6	18,006	5	0	0	0	0	20	20	0	0	0	0
Activity Total	4.2	143,337	35.5	0	5	0	0						
		31,008	21.8%		20.0%			21.6%	19,066	0	0	11,943	0

Activity **06-04**

Deliver Product

Activity Note

Activity Driver Candidates Production (Explosive) Batches

	FTE	Cost	People Time	Maintena nce	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Pump 509 to Area-B	0.5	14,405	4	0	0	0	0	25	25	0	0	0	0
2 Loaded Tank car to Area B	0.5	14,405	4	0	0	0	0	25	25	0	0	0	0
3 Come of 521 tanks and loaded in top of tank car thu line	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.9	28,810	8	0	0	0	0						
		7,203	25.0%					25.0%	7,203	0	0	0	0

Activity **06-05**

Conduct Training

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	Maintena nce	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Team managers turn in training records to secretary	0.2	7,203	2	0	0	0	0	40	20	0	0	0	20
2 Maintain training records	0.1	1,801	0.5	0	0	0	0	40	20	0	0	0	20
3 QM Meeting once a month	0.5	14,405	4	0	0	0	0	20	20	0	0	0	0
4 Employee Development	0.5	14,405	4	0	0	0	0	30	30	0	0	0	0
5 Safety meetings	0.2	7,203	2	0	0	0	0		0	0	0	0	0

	FTE	Cost	People Time	Maintenance	Oper Supplies	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
Activity Total	1.5	45,016	12.5	0	0	0	0						
		10,804	24.0%					24.0%	9,003	0	0	0	1,801

Activity **06-06**

Manage Operations

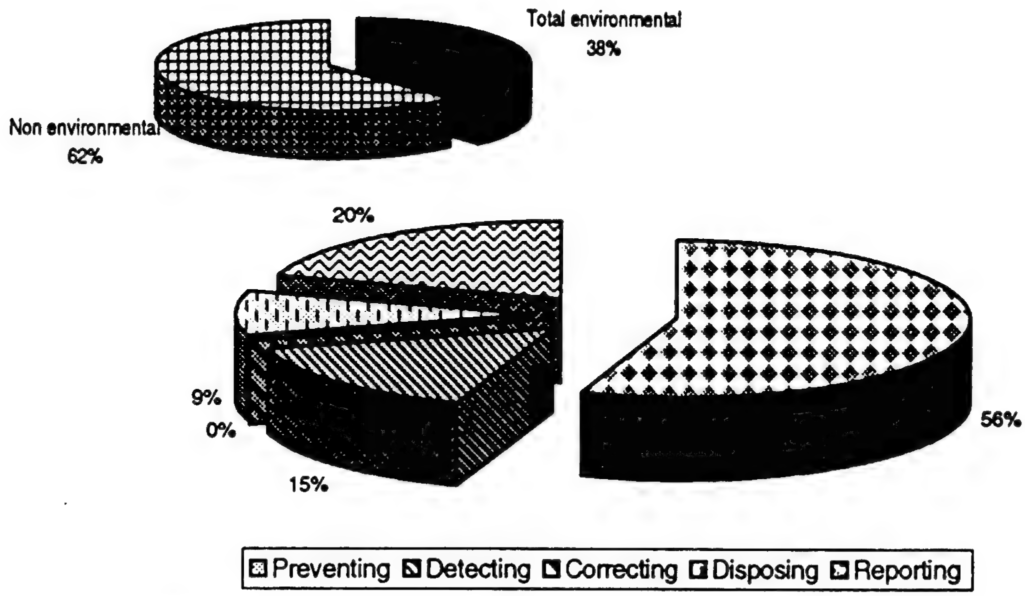
Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	Maintena nce	Oper Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Update SPCC plan	0.1	3,601	1	0	0	0	0	100	100	0	0	0	0
2 Switched all records from sperylink to Word Perfect	0.1	1,801	0.5	0	0	0	0		0	0	0	0	0
3 Keep lost time records	0.1	3,601	1	0	0	0	0		0	0	0	0	0
4 Meetings (Quality, Production, Environmental, Safety etc)	0.2	14,637	2	1	0	0	0	20	20	0	0	0	0
5 Do Reports on computer	0.1	3,601	1	0	0	0	0		0	0	0	0	0
6 Retype departmental SOP's as theyre revised	0.1	1,801	0.5	0	0	0	0	15	15	0	0	0	0
7 Compile and send SARA 312/313 reports to Enviornmental Dept	0.1	1,801	0.5	0	0	0	0	100	0	0	0	0	100
8 Separate paper recyclable/nonrecyclable	0.0	0	0	0	0	0	0	100	0	0	0	100	0
9 Reinforce positive actions/behaviors	0.1	1,801	0.5	0	0	0	0		0	0	0	0	0
10 Assess/ensure ongoing compliance with cnvironmental permits & regs	0.6	18,006	5	0	0	0	0	100	50	0	0	0	50
11 Original forms for department & keep on hand	0.1	14,194	0.5	0	4	0	0	10	0	0	0	0	10
12 Prepare bldg/Shift logs writeup	0.1	3,601	1	0	0	0	0	10	0	0	0	0	10
13 Estimate production equipment req's	0.2	5,402	1.5	0	0	0	0		0	0	0	0	0
14 Tank farm operator sends end of month inventoyr figures to me to send to acctg	0.2	7,203	2	0	0	0	0		0	0	0	0	0
15 Fill out time sheets	0.4	12,604	3.5	0	0	0	0		0	0	0	0	0
16 Request funding provide justification for projects	0.1	1,801	0.5	0	0	0	0	15	15	0	0	0	0
17 Do inventory report	0.1	3,601	1	0	0	0	0	5	5	0	0	0	0
18 Check with higher supervison for anything he wants done	0.2	7,203	2	0	0	0	0		0	0	0	0	0
19 Vision/Lead department initiatives to support HOC strategic goal	0.1	3,601	1	0	0	0	0	25	25	0	0	0	0
20 Maintain log of inventory throughout month for end of month report to accounting	0.2	5,402	1.5	0	0	0	0		0	0	0	0	0
21 Check groupwise for mail	0.1	1,801	0.5	0	0	0	0		0	0	0	0	0
22 Type reports	0.1	3,601	1	0	0	0	0	20	20	0	0	0	0
23 Receive info from operators to put n inventory reports	0.1	3,601	1	0	0	0	0		0	0	0	0	0

24 Pick up all paperwork for the past 24 hours	0.3	9,003	2.5	0	0	0	0		0	0	0	0	0
25 Type memos	0.1	3,601	1	0	0	0	0		0	0	0	0	0
26 Dept head run groupwise sending & receiving messages	0.1	3,601	1	0	0	0	0		0	0	0	0	0
Activity Total	4.0	140,470	33.5	1	4	0	0						
		30,456	23.0%	20.0%	10.0%			21.7%	17,873	0	0	0	12,583
Session Total	27.0	1,000,751	228	20	10	0	0						
		237,286	24.7%	20.2%	14.0%				162,826	0	0	60,076	14,384

Utilities, Area B Water/Wastewater



Session Number	07
Group	Utilities, Area B Water/Wastewater
Organization	Production Support

Category	Cost	% of Total	% of Environmental
Preventing	196,865	21.0%	55.4%
Detecting	53,845	5.7%	15.2%
Correcting	170	0.0%	0.0%
Disposing	32,683	3.5%	9.2%
Reporting	71,793	7.6%	20.2%
Total environmental	355,355	37.9%	100.0%
Non environmental	583,162	62.1%	
Cost	938,517	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
07	Utilities, Area B Water/Wastewater								
07-01	Receive Wastewater	86,151	0	0	0	11,965	98,117	143,585	68.3%
07-02	Treat Wastewater	23,931	53,845	0	5,983	59,827	143,585	215,378	66.7%
07-03	Maintain Equipment	5,228	0	0	0	0	5,228	21,783	24.0%
07-04	Ordering Supplies	0	0	0	0	0	0	0	
07-05	Train People	0	0	0	0	0	0	0	
07-06	Manage Operations	8,637	0	54	0	0	8,691	45,884	18.9%
07-07	Start Processing	2,861	0	116	0	0	2,977	88,779	3.4%
07-08	Processing Water	70,057	0	0	26,700	0	96,757	423,107	22.9%
Subtotal Utilities, Area B Water/Wastewater		196,865	53,845	170	32,683	71,793	355,355	938,517	37.9%

Holston Activity and Task Summary

Session 07 Utilities, Area B Water/Wastewater

Date 7/31/97 6 Participants Eddie Galloway,Lyle Housewright, Allen Parris, Larry Pierce,Jim Quiller, B.J. Robbins Observers Ennis, Glen, Keith, Alan

Time 8:00 a.m. FTE: 25 122 Years Experience Note

Activity **07-01**

Receive Wastewater

Activity Note

Activity Driver Candidates Production

	FTE	Cost	People Water	People Waste	Maint Water	Maint Waste	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Check Pumps, Valves, Motors and Instruments	0.0	107,689	0	9	0	0	0	80	80	0	0	0	0
2 Clean Equipment	0.0	11,965	0	1	0	0	0		0	0	0	0	0
3 Keep Records for State of Tennessee	0.0	5,983	0	0.5	0	0	0	100	0	0	0	0	100
4 State License Wastewater	0.0	5,983	0	0.5	0	0	0	100	0	0	0	0	100
5 Request Information on Leaks, Power Failure, Spills	0.0	5,983	0	0.5	0	0	0		0	0	0	0	0
6 Look at Sample Results Last 24 Hours	0.0	5,983	0	0.5	0	0	0		0	0	0	0	0
Activity Total	0.0	143,585	0	12	0	0	0						
		98,117		68.3%				68.3%	86,151	0	0	0	11,965

Activity **07-02**

Treat Wastewater

Activity Note

Activity Driver Candidates Production

	FTE	Cost	People Water	People Waste	Maint Water	Maint Waste	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Safety Meeting	0.0	17,948	0	1.5	0	0	0		0	0	0	0	0
2 Fill Truck up with Gas, Check Oil	0.0	5,983	0	0.5	0	0	0		0	0	0	0	0
3 Check on What Happened During Operations Before Me	0.0	5,983	0	0.5	0	0	0		0	0	0	0	0
4 Check Chemicals Inventory	0.0	5,983	0	0.5	0	0	0		0	0	0	0	0
5 Run Tests - COD,BOD,SS Solids,MLSS,MLVSS,NO2,NO3,NH3,PH,Temp,CL,F/M,SVI,Detent	0.0	107,689	0	9	0	0	0	100	0	50	0	0	50
6 Look at Lab Results-Make Changes as Required	0.0	23,931	0	2	0	0	0		0	0	0	0	0
7 Dewater Sludge	0.0	5,983	0	0.5	0	0	0		0	0	0	0	0
8 Receive Calstic & HCL	0.0	5,983	0	0.5	0	0	0	100	100	0	0	0	0
9 Hydraulic Hose Break	0.0	5,983	0	0.5	0	0	0	100	100	0	0	0	0
10 Haul Sludge to Landfill	0.0	5,983	0	0.5	0	0	0	100	0	0	0	100	0
11 Mix Chemicals	0.0	5,983	0	0.5	0	0	0		0	0	0	0	0
12 Backwash Filter	0.0	0	0	0	0	0	0		0	0	0	0	0
13 Check Charts and Controls	0.0	11,965	0	1	0	0	0	100	100	0	0	0	0

Holston Activity and Task Summary

Session 07 Utilities, Area B Water/Wastewater

	FTE	Cost	People Water	People Waste	Maint Water	Maint Waste	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
14 Report Spills to HDC-State	0.0	5,983	0	0.5	0	0	0	100	0	0	0	0	100
Activity Total	0.0	215,378	0	18	0	0	0						
		143,585		66.7%				66.7%	23,931	53,845	0	5,983	59,827

Activity **07-03**

Maintain Equipment

Activity Note

Activity Driver Candidates Treating

	FTE	Cost	People Water	People Waste	Maint Water	Maint Waste	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Calibrate PH Meter	0.0	1,089	0	0	0	0.5	0	100	100	0	0	0	0
2 Electrical, Instrumental, Mechanical Repair	0.0	20,694	0	0	0	9.5	0	20	20	0	0	0	0
Activity Total	0.0	21,783	0	0	0	10	0						
		5,228				24.0%		24.0%	5,228	0	0	0	0

Activity **07-04**

Ordering Supplies

Activity Note

Activity Driver Candidates Demand

	FTE	Cost	People Water	People Waste	Maint Water	Maint Waste	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Order Sodium Hopochorite and Alum	0.0	0	0	0	0	0	0		0	0	0	0	0
2 Write Receiving Reports	0.0	0	0	0	0	0	0		0	0	0	0	0
3 Stire Riin Req,	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.0	0	0	0	0	0	0						
		0						#Num!	0	0	0	0	0

Activity **07-05**

Train People

Activity Note

Activity Driver Candidates

	FTE	Cost	People Water	People Waste	Maint Water	Maint Waste	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Train on Air Permits	0.0	0	0	0	0	0	0	100	100	0	0	0	0
2 Take Training for State Liscence for Well	0.0	0	0	0	0	0	0		0	0	0	0	0
3 Safety Training	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.0	0	0	0	0	0	0						
		0						#Num!	0	0	0	0	0

Activity **07-06**

Manage Operations

Activity Note

Activity Driver Candidates

	FTE	Cost	People Water	People Waste	Maint Water	Maint Waste	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Check Time	0.2	5,398	1	0	0	0	0		0	0	0	0	0
2 Set up Mandatory Training	0.1	2,699	0.5	0	0	0	0	50	50	0	0	0	0

	FTE	Cost	People Water	People Waste	Maint Water	Maint Waste	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
3 Fill Out Reports, Etc.	0.0	0	0	0	0	0	0	100	0	0	0	0	100
4 Write MOE's for New Equipment	0.1	2,699	0.5	0	0	0	0	5	5	0	0	0	0
5 Revise SOPs	0.1	2,699	0.5	0	0	0	0	3	3	0	0	0	0
6 Write Work Orders	0.2	5,398	1	0	0	0	0	2	1	0	1	0	0
7 Print Operation Time Sheets	0.1	2,699	0.5	0	0	0	0		0	0	0	0	0
8 Order Heating Fuel	0.1	2,699	0.5	0	0	0	0		0	0	0	0	0
9 Fill out Employee Development Forms	0.1	2,699	0.5	0	0	0	0		0	0	0	0	0
10 Rewrite Spill Plans	0.1	2,699	0.5	0	0	0	0	100	100	0	0	0	0
11 Attend Mandatory Training	0.2	5,398	1	0	0	0	0	50	50	0	0	0	0
12 Meetings	0.5	10,796	2	0	0	0	0	15	15	0	0	0	0
Activity Total	2.1	45,884	8.5	0	0	0	0						
		8,691	18.9%					18.9%	8,637	0	54	0	0

Activity 07-07

Start Processing

	FTE	Cost	People Water	People Waste	Maint Water	Maint Waste	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
			Activity Note										
			Activity Driver Candidates				Demand for Processing						
1 Clear Intake on River	0.1	2,699	0.5	0	0	0	0		0	0	0	0	0
2 Start and Stop River Pumps, Alternately as Needed	0.2	5,398	1	0	0	0	0		0	0	0	0	0
3 Run Screens at Pump House Every 2 Hours to Pick Up Grass etc. from River	0.6	14,298	2.5	0	1	0	0		0	0	0	0	0
4 Check River Pumps	0.6	13,495	2.5	0	0	0	0		0	0	0	0	0
5 Check Safety Showers Weekly	0.4	8,097	1.5	0	0	0	0		0	0	0	0	0
6 Be able to Run Boat Motor and Go to Intake and Clean	0.1	2,699	0.5	0	0	0	0		0	0	0	0	0
7 Put All Pumps, Start Up All Chemicals Due to Power Failure	0.1	2,699	0.5	0	0	0	0		0	0	0	0	0
8 Repair Water Line Breaks	0.1	3,502	0.5	0	1	0	0		0	0	0	0	0
9 Call Trouble Shooters When Needed	0.2	6,201	1	0	1	0	0	1	0	0	1	0	0
10 Measure Lime and Alum Each Month	0.4	8,097	1.5	0	0	0	0	2	2	0	0	0	0
11 Take Monthly Reading of All Drinking Water Use in Area. Report to City Water De	0.4	8,097	1.5	0	0	0	0		0	0	0	0	0
12 Keep Check While Digging	0.2	5,398	1	0	0	0	0		0	0	0	0	0
13 Check on Spill Upstream from Intake	0.1	2,699	0.5	0	0	0	0	100	100	0	0	0	0
14 Write Work Orders	0.1	2,699	0.5	0	0	0	0	2	0	0	2	0	0
15 Relieve Load Operator in His Absence	0.1	2,699	0.5	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 07 Utilities, Area B Water/Wastewater

Activity 07-08

Processing Water

Activity Note

Activity Driver Candidates

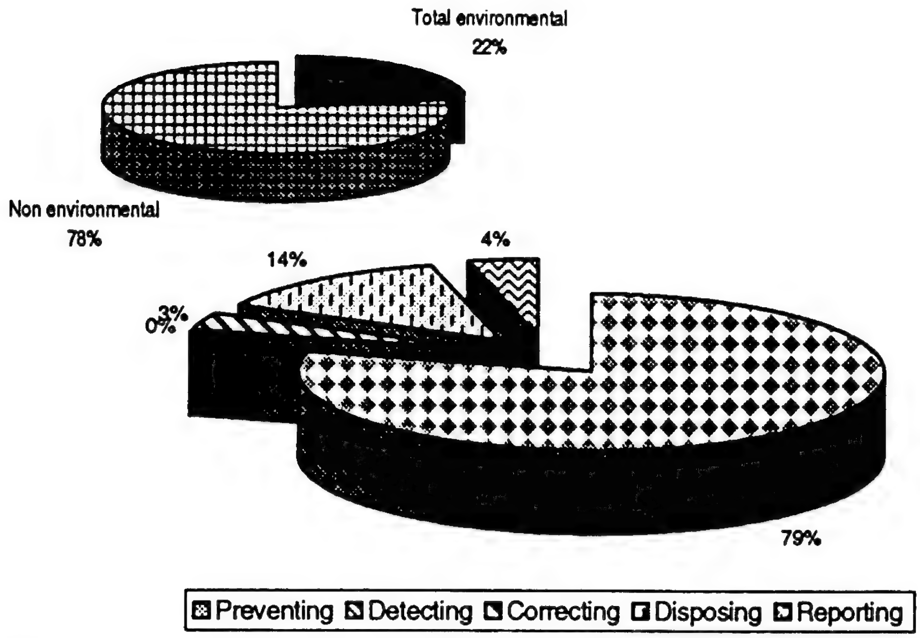
	FTE	Cost	People Water	People Waste	Maint Water	Maint Waste	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
Activity Total	4.0	88,779	16	0	3	0	0						
		2,977	3.4%		0.3%			3.4%	2,861	0	116	0	0
1 Operate Filter Plant	1.0	21,593	4	0	0	0	0		0	0	0	0	0
2 Check Air Compressors	0.5	11,599	2	0	1	0	0	5	5	0	0	0	0
3 Check Vaccuum Primer Pumps	0.5	11,198	2	0	0.5	0	0		0	0	0	0	0
4 Choke Back on Pump if Resovoir Runs Over	0.1	2,699	0.5	0	0	0	0	100	100	0	0	0	0
5 Check Sump Pumps	0.2	5,800	1	0	0.5	0	0		0	0	0	0	0
6 Check Fuel Oil for Leaks Daily	0.2	5,398	1	0	0	0	0	100	100	0	0	0	0
7 Switch Rectifiers Weekly	0.2	5,398	1	0	0	0	0		0	0	0	0	0
8 Start Desludged Valves	0.6	14,298	2.5	0	1	0	0		0	0	0	0	0
9 Check PH Meter	0.4	8,097	1.5	0	0	0	0	100	100	0	0	0	0
10 On Influent, switch from 4" valve to 8" Valve as Volume Changes	0.2	5,398	1	0	0	0	0		0	0	0	0	0
11 Grease Equipment	0.2	6,201	1	0	1	0	0		0	0	0	0	0
12 Power Filure-Get Equip and Process Goods in Service	0.2	5,398	1	0	0	0	0		0	0	0	0	0
13 Operate Auto, Valve Wrench	0.4	8,900	1.5	0	1	0	0		0	0	0	0	0
14 Sign Digging Permits	0.2	5,398	1	0	0	0	0	5	5	0	0	0	0
15 Calibrate PH Meter	0.2	7,004	1	0	2	0	0		0	0	0	0	0
16 Change Clothes	0.2	5,398	1	0	0	0	0		0	0	0	0	0
17 Check Over Operation	1.2	26,991	5	0	0	0	0	20	20	0	0	0	0
18 Run Diesel Pump Weekly	0.2	6,201	1	0	1	0	0		0	0	0	0	0
19 Keep Watch on Gas Furnace at Bldg 203	0.2	6,201	1	0	1	0	0		0	0	0	0	0
20 Keep Check on Sodium Hypochlorite System for Leak	0.7	17,399	3	0	1.5	0	0	100	100	0	0	0	0
21 Grease All Equip Once a Week, At Pump House and Filter Plant	0.5	10,796	2	0	0	0	0		0	0	0	0	0
22 Check Vehicle at Start of Shift for Possible Damage Prior to the Shift	0.2	5,398	1	0	0	0	0		0	0	0	0	0
23 Check Buildings 217, 218, Lift Station and Sewer Plant	0.6	13,495	2.5	0	0	0	0	100	100	0	0	0	0
24 Exercise RW FW DW Valves	0.2	5,398	1	0	0	0	0		0	0	0	0	0
25 Operate Spent Backwash Pumps	0.2	6,602	1	0	1.5	0	0	100	0	0	0	100	0
26 Take Report from Manager Jim Relewing	0.4	8,097	1.5	0	0	0	0		0	0	0	0	0
27 Read Log Book	0.4	8,097	1.5	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 07 Utilities, Area B Water/Wastewater

28 Moring Report	0.5	10,796	2	0	0	0	0		0	0	0	0	0
29 Collect and Run Samples on Water	1.0	21,593	4	0	0	0	0	5	5	0	0	0	0
30 Backwash Filter	0.6	13,897	2.5	0	0.5	0	0	100	0	0	0	100	0
31 Adjust Chemical Flow Hourly as Needed	0.9	19,696	3.5	0	1	0	0	5	5	0	0	0	0
32 Keep FW Basin Levels at Correct Levels	0.6	13,495	2.5	0	0	0	0	100	100	0	0	0	0
33 Keep Area Clean	0.4	8,097	1.5	0	0	0	0		0	0	0	0	0
34 Inspect All Equipment	0.4	8,499	1.5	0	0.5	0	0	10	10	0	0	0	0
35 Keep Safety Informed	0.2	5,398	1	0	0	0	0		0	0	0	0	0
36 Notify Fire Dept When Water is Cut Off For Fire Sprinkler System	0.1	2,699	0.5	0	0	0	0		0	0	0	0	0
37 Run Sreens at River Pump and Check Equipment	0.2	6,201	1	0	1	0	0	5	5	0	0	0	0
38 Report Things About Operations to Team Manager by Computer	0.2	5,398	1	0	0	0	0		0	0	0	0	0
39 Take Inventory on Chemical Monthly	0.4	8,097	1.5	0	0	0	0		0	0	0	0	0
40 Keep Check on All Operations	1.0	21,593	4	0	0	0	0		0	0	0	0	0
41 Operate Alum Sludge Pumping Station	0.2	6,201	1	0	1	0	0	100	0	0	0	100	0
42 Sign Out Keys	0.6	13,495	2.5	0	0	0	0		0	0	0	0	0
43 Rotate Pumps Due to Work Load	0.4	8,097	1.5	0	0	0	0		0	0	0	0	0
44 Check Chemicals	0.2	5,398	1	0	0	0	0		0	0	0	0	0
Activity Total	18.9	423,107	76	0	16	0	0						
		96,757	22.7%		29.4%			22.9%	70,057	0	0	26,700	0
Session Total	25.0	938,517	100.5	30	19	10	0						
		355,355	19.3%	67.3%	24.8%	24.0%			196,865	53,845	170	32,683	71,793

Utilities & Utilities Area A



Session Number	08
Group	Utilities & Utilities Area A
Organization	Production Support

Category	Cost	% of Total	% of Environmental
Preventing	212,859	17.1%	78.9%
Detecting	-	0.0%	0.0%
Correcting	9,377	0.8%	3.5%
Disposing	37,201	3.0%	13.8%
Reporting	10,263	0.8%	3.8%
Total environmental	269,700	21.6%	100.0%
Non environmental	977,867	78.4%	
Cost	1,247,567	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
08	Utilities & Utilities Area A								
08-01	Dispose of Waste	13,437	0	0	34,066	0	47,503	58,926	80.6%
08-02	Make Steam	117,216	0	4,035	0	3,051	124,303	545,379	22.8%
08-03	Treat Water	71,254	0	0	3,135	0	74,390	416,842	17.8%
08-04	Receive Coal	0	0	0	0	1,870	1,870	110,621	1.7%
08-05	Make Air	0	0	0	0	0	0	8,958	0.0%
08-06	Manage Operations	10,951	0	5,342	0	5,342	21,635	106,841	20.3%
Subtotal Utilities & Utilities Area A		212,859	0	9,377	37,201	10,263	269,700	1,247,567	21.6%

Holston Activity and Task Summary

Session 08 Utilities & Utilities Area A

Date 7/31/97 — 6 Participants: Bill Brinkley,Clyde Grindstaff, John Light,Harlan Parvin, Micheal Steffy, Earl Williams — Observers: Ennis Hawkins, Alan Stratton, Keith Hunziker, Glenn Peters

Time 1:00 pm — FTE: 25 107 Years Experience — Note

Activity **08-01**

Dispose of Waste

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	Maintenance	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Check for Hydraulic Oil Leak in Building 11	0.1	5,342	1	0	0	0	0	100	100	0	0	0	0
2 Wash Water Filter	0.2	10,684	2	0	0	0	0	35	0	0	0	35	0
6 Check Wast Water Pumps	0.1	8,958	1	1	0	0	0	50	50	0	0	0	0
8 Load Out Fly-Ash & Cylinders	0.6	30,326	5	1	0	0	0	100	0	0	0	100	0
11 Walk Pipe Line to Check for Leak	0.0	3,616	0	1	0	0	0	100	100	0	0	0	0
Activity Total	1.0	58,926	9	3	0	0	0						
		47,503	80.0%	83.3%				80.6%	13,437	0	0	34,066	0

Activity **08-02**

Make Steam

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	Maintenance	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
0 Header	0.0	0	0	1	0	0	0		0	0	0	0	0
1 Check 90# Steam Pressure & Temp	0.5	21,519	4	0	0	0	0		0	0	0	0	0
2 Run Water Samples on Water. Boiler on Incoming	0.5	21,519	4	0	0	0	0		0	0	0	0	0
3 Take Sample	0.2	10,759	2	0	0	0	0		0	0	0	0	0
5 Keep Check on Coal Going to Boiler	0.3	16,139	3	0	0	0	0		0	0	0	0	0
6 When Switch Boiler We Start Fires in Other Boiler if We Have Leak in Boiler Plat	0.1	8,996	1	1	0	0	0	10	10	0	0	0	0
7 Maintain Proper Air to Fuel Ratio	0.7	32,278	6	0	0	0	0	100	100	0	0	0	0
8 Log Up Waste Heat Boilers	0.6	26,898	5	0	0	0	0		0	0	0	0	0
9 Grease Equipment and Oil Checks	0.5	21,519	4	0	0	0	0		0	0	0	0	0
10 Monitor Steam Pressure	0.2	10,759	2	0	0	0	0	5	5	0	0	0	0
11 Maintain Precipators	0.3	19,755	3	1	0	0	0	100	100	0	0	0	0
12 Check Feedwater Pump	0.1	8,996	1	1	0	0	0		0	0	0	0	0
13 Keep Boilers in Good Condition	0.2	17,991	2	2	0	0	0	50	50	0	0	0	0
14 Check DA Heater and Condensate Levels	0.6	26,898	5	0	0	0	0		0	0	0	0	0
15 Blow Soot When Ready on Group	0.3	19,755	3	1	0	0	0		0	0	0	0	0
16 Run Generator Weekly	0.1	5,380	1	0	0	0	0	100	100	0	0	0	0
17 Calibrate O2 Sensor and Opacitor	0.0	0	0	0	0	0	0	100	100	0	0	0	0

Session 08 Utilities & Utilities Area A

18 Check Waste Heat Boiler	0.6	26,898	5	0	0	0	0		0	0	0	0	0
19 Burn Down Fires	0.2	10,759	2	0	0	0	0		0	0	0	0	0
20 Clean Up Bldg Every Shift	0.5	21,519	4	0	0	0	0		0	0	0	0	0
21 Keep Hopper on Front and Back of Boiler Clean	0.2	10,759	2	0	0	0	0		0	0	0	0	0
23 Run Flyash System	0.6	34,131	5	2	0	0	0	100	95	0	0	0	5
25 Clean Fires	0.5	21,519	4	0	0	0	0		0	0	0	0	0
26 Keep Check on Condensate Polisher System	0.5	21,519	4	0	0	0	0	10	10	0	0	0	0
27 Check ID Draft Pressure and Force Air Pressure	0.2	10,759	2	0	0	0	0		0	0	0	0	0
28 Basement Operator First Make a Round or Check Equipment	0.3	16,139	3	0	0	0	0		0	0	0	0	0
29 Check Polymer Tank and Pumps	0.1	5,380	1	0	0	0	0		0	0	0	0	0
31 Keep Fans in Good Condition	0.2	10,759	2	0	0	0	0		0	0	0	0	0
32 Changed Chart on Operator Every Shift	0.6	26,898	5	0	0	0	0	5	0	0	0	0	5
33 Check all Around the Boiler	0.5	21,519	4	0	0	0	0		0	0	0	0	0
34 Monitor Precipitators	0.2	10,759	2	0	0	0	0	100	100	0	0	0	0
35 Grease and Oil All Equipment	0.3	16,139	3	0	0	0	0		0	0	0	0	0
55 Restart Equipment After Power Failure	0.2	10,759	2	0	0	0	0	75	37.5	0	37.5	0	0
Activity Total	10.9	545,379	96	9	0	0	0						
		124,303	21.2%	45.6%				22.8%	117,216	0	4,035	0	3,051

Activity **08-03**

Treat Water

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	Maintenance	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Fill up Storage Tanks	0.2	10,684	2	0	0	0	0		0	0	0	0	0
2 Check Storage Tanks Level	0.5	21,368	4	0	0	0	0		0	0	0	0	0
3 Change Drum of Bleach	0.2	10,684	2	0	0	0	0		0	0	0	0	0
5 Check Basins Level	0.5	21,368	4	0	0	0	0		0	0	0	0	0
6 Check Brine Pump	0.5	21,368	4	0	0	0	0		0	0	0	0	0
8 Diesel Tanks	0.6	26,710	5	0	0	0	0	100	100	0	0	0	0
9 Back Wash Chiller	0.2	10,684	2	0	0	0	0		0	0	0	0	0
10 Check River for Oil Slicks	0.1	5,342	1	0	0	0	0	100	100	0	0	0	0
11 Keep Check on Lift Station	0.5	24,984	4	1	0	0	0	50	50	0	0	0	0
12 Get Water Meter Readings	0.5	21,368	4	0	0	0	0		0	0	0	0	0
13 Change High Head Pumps as Needed	0.1	8,958	1	1	0	0	0		0	0	0	0	0
14 Make Check on Equipment for Leaks of Oil, Water and Steam	0.5	21,368	4	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 08 Utilities & Utilities Area A

	FTE	Cost	People Time	Maintenance	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
15 Check Pump House Pump and Bldg 11A	0.2	10,684	2	0	0	0	0		0	0	0	0	0
16 Run Sample	0.5	21,368	4	0	0	0	0		0	0	0	0	0
17 Check Pond Waste Water	0.5	21,368	4	0	0	0	0	50	50	0	0	0	0
18 Keep PH 7.5 to 8 by Raising Pump Pressure	0.6	26,710	5	0	0	0	0		0	0	0	0	0
19 Fill Alum Hopper	0.2	10,684	2	0	0	0	0		0	0	0	0	0
20 Check for Leaks	0.2	10,684	2	0	0	0	0	100	100	0	0	0	0
21 Check to Ensure all Equipment has Cooling Water on it	0.5	21,368	4	0	0	0	0		0	0	0	0	0
22 Calibrate PH Instrumentation	0.1	5,342	1	0	0	0	0	100	100	0	0	0	0
23 Switch Filter Water Pumps	0.5	21,368	4	0	0	0	0		0	0	0	0	0
24 Check Filter Water Pumps	0.2	10,684	2	0	0	0	0		0	0	0	0	0
25 Check Intakes	0.2	10,684	2	0	0	0	0		0	0	0	0	0
26 Reg Brine Softeners	0.2	10,684	2	0	0	0	0		0	0	0	0	0
27 Clean Filter Water Basin Every Year. Water goes to Waste Water Pond	0.1	8,958	1	1	0	0	0	35	0	0	0	35	0
28 Wash River Water Screens	0.2	10,684	2	0	0	0	0		0	0	0	0	0
29 Check Clear Well	0.2	10,684	2	0	0	0	0		0	0	0	0	0
Activity Total	8.6	416,842	76	3	0	0	0						
		74,390	17.6%	28.3%				17.8%	71,254	0	0	3,135	0

Activity 08-04

Receive Coal

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	Maintenance	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Other Operators Unload Coal	0.8	37,394	7	0	0	0	0	5	0	0	0	0	5
2 Run Coal Samples	0.1	5,342	1	0	0	0	0		0	0	0	0	0
3 Start Coal Crusher	0.1	6,287	0.5	1	0	0	0		0	0	0	0	0
4 Start Bucket Elevator	0.1	6,287	0.5	1	0	0	0		0	0	0	0	0
5 Break Down Coal Cars	0.2	10,684	2	0	0	0	0		0	0	0	0	0
6 Start Short Belt	0.1	6,287	0.5	1	0	0	0		0	0	0	0	0
7 Clean Coal Equipment	0.7	35,668	6	1	0	0	0		0	0	0	0	0
8 Start Coal Conveyor	0.1	2,671	0.5	0	0	0	0		0	0	0	0	0
Activity Total	2.0	110,621	18	4	0	0	0						
		1,870	1.9%	0.0%				1.7%	0	0	0	0	1,870

Activity 08-05

Make Air

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	Maintenance	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting

Holston Activity and Task Summary

Session 08 Utilities & Utilities Area A

	FTE	Cost	People Time	Maintenance	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Keep Air Compressors in Good Condition	0.0	3,616	0	1	0	0	0		0	0	0	0	0
2 Run Diesel Air Compressor	0.1	5,342	1	0	0	0	0		0	0	0	0	0
Activity Total	0.1	8,958	1	1	0	0	0						
		0	0.0%	0.0%				0.0%	0	0	0	0	0

Activity **08-06**

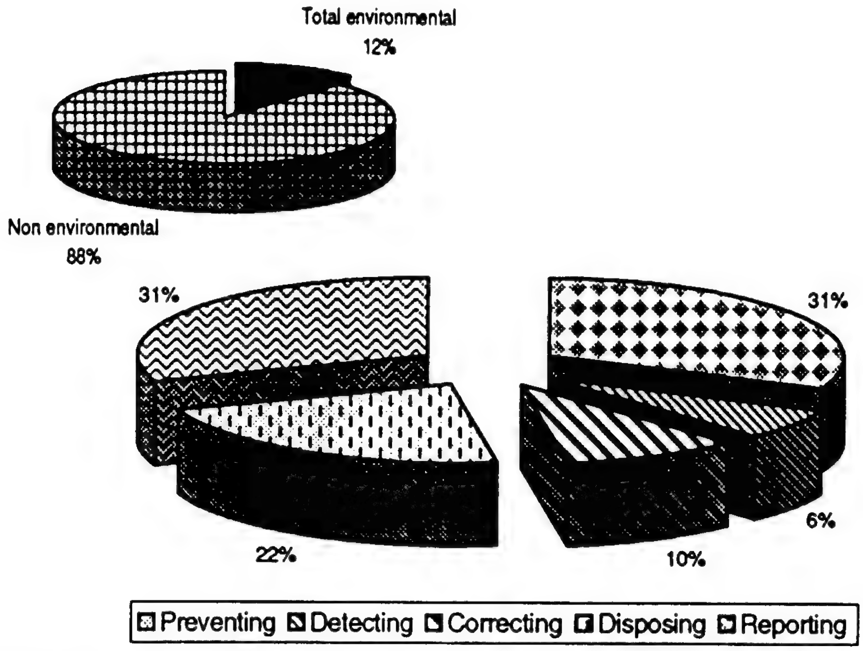
Manage Operations

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	Maintena nce	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
4 Update Time Keeper	0.1	5,342	1	0	0	0	0		0	0	0	0	0
5 Order Supplies, Chemicals, Charts, Log Sheets	0.0	0	0	0	0	0	0		0	0	0	0	0
7 Check With Operators to See if There Were Any Problems on Night Shift	0.2	10,684	2	0	0	0	0		0	0	0	0	0
10 Fill out Emissions Report on Boiler	0.1	5,342	1	0	0	0	0	100	0	0	0	0	100
12 Talk with Maintenance Foreman About any Problems	0.1	5,342	1	0	0	0	0		0	0	0	0	0
14 Update SOP	0.0	0	0	0	0	0	0		0	0	0	0	0
15 Read Log Book	0.1	5,342	1	0	0	0	0		0	0	0	0	0
17 Write Work Orders	0.0	0	0	0	0	0	0		0	0	0	0	0
19 Log up Chillers	0.0	0	0	0	0	0	0		0	0	0	0	0
28 Do Special Projects	0.2	10,684	2	0	0	0	0		0	0	0	0	0
29 Have Safety Meetings	0.2	10,684	2	0	0	0	0		0	0	0	0	0
30 Required Training	0.7	32,052	6	0	0	0	0	30	30	0	0	0	0
31 See that Leaks are Repaired	0.1	5,342	1	0	0	0	0	75	0	0	75	0	0
33 Help Other Operators and Change Equipment as Needed	0.1	5,342	1	0	0	0	0		0	0	0	0	0
34 Write Work Orders to Maintenance	0.2	10,684	2	0	0	0	0	25	12.5	0	12.5	0	0
Activity Total	2.3	106,841	20	0	0	0	0						
		21,635	20.2%					20.3%	10,951	0	5,342	0	5,342
Session Total	25.0	1,247,567	220	20	0	0	0						
		269,700	20.6%	37.2%					212,859	0	9,377	37,201	10,263

Safety



Session Number	09
Group	Safety
Organization	Support

Category	Cost	% of Total	% of Environmental
Preventing	12,339	3.7%	31.3%
Detecting	2,522	0.8%	6.4%
Correcting	3,788	1.1%	9.6%
Disposing	8,646	2.6%	22.0%
Reporting	12,077	3.6%	30.7%
Total environmental	39,371	11.7%	100.0%
Non environmental	296,848	88.3%	
Cost	336,220	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
09	Safety								
09-01	Monitor Safety Process	2,354	2,522	2,051	0	0	6,926	92,460	7.5%
09-02	Communicate Safety Information	1,664	0	0	0	3,362	5,026	28,579	17.6%
09-03	Manage Safety Process	3,429	0	0	0	925	4,354	114,315	3.8%
09-04	Neutralize Explosives	4,035	0	0	7,397	6,724	18,156	23,535	77.1%
09-05	Respond to emergencies	0	0	1,064	1,064	1,066	3,194	20,173	15.8%
09-06	Comply with Regulations	336	0	672	168	0	1,177	18,492	6.4%
09-07	Insuring Regulatory Compliance	521	0	0	17	0	538	38,665	1.4%
Subtotal Safety		12,339	2,522	3,788	8,646	12,077	39,371	336,220	11.7%

Holston Activity and Task Summary

Session 09 Safety

Date 8/1/97 3 Participants Larry Wolverton, Ned Stacy, Phil Ketron Observers Ennis Hawkins, Alan Stratton, Keith Hunziker, Glenn Peters

Time 8:00 am FTE: 9 99 Years Experience Note

Activity **09-01**

Monitor Safety Process

Activity Note

	Task	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
					Activity Driver Candidates				Production Volume					
1	Coordinate Response to OSHA inspections	0.0	0	0	0	0	0	0		0	0	0	0	0
2	Earth cover inspection on Magazines (5 years)	0.0	1,681	0.5	0	0	0	0		0	0	0	0	0
3	Yearly inspection of explosives in magazines	0.1	3,362	1	0	0	0	0	1	0	0	1	0	0
4	Accident investigation	0.2	6,724	2	0	0	0	0	30	0	0	30	0	0
5	Safety Audits	0.3	11,768	3.5	0	0	0	0	20	20	0	0	0	0
6	Safety Inspections	0.7	25,216	7.5	0	0	0	0	10	0	10	0	0	0
7	Inspect Magazine condition	0.1	3,362	1	0	0	0	0		0	0	0	0	0
8	180 Day shutdown inspection	0.3	11,768	3.5	0	0	0	0		0	0	0	0	0
9	Inspect explosive shipments	0.4	15,130	4.5	0	0	0	0		0	0	0	0	0
10	Inspect On-post vehicles	0.4	13,449	4	0	0	0	0		0	0	0	0	0
11	Some involvement with radiation protection program	0.0	0	0	0	0	0	0		0	0	0	0	0
	Activity Total	2.5	92,460	27.5	0	0	0	0						
			6,926	7.5%					7.5%	2,354	2,522	2,051	0	0

Activity **09-02**

Communicate Safety Information

Activity Note

	Task	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
					Activity Driver Candidates									
1	Prepare morning reports	0.2	6,724	2	0	0	0	0	40	0	0	0	0	40
2	Prepare weekly summary report	0.1	5,043	1.5	0	0	0	0		0	0	0	0	0
3	Publish monthly health, safety, environment newsletter	0.1	5,043	1.5	0	0	0	0	33	33	0	0	0	0
4	Issue road closing notices	0.1	3,362	1	0	0	0	0		0	0	0	0	0
5	Maintain safety performance statistics for the plant	0.2	6,724	2	0	0	0	0	10	0	0	0	0	10
6	Prepare annual review response to safety waivers needs	0.0	1,681	0.5	0	0	0	0		0	0	0	0	0
	Activity Total	0.8	28,579	8.5	0	0	0	0						
			5,026	17.6%					17.6%	1,664	0	0	0	3,362

Holston Activity and Task Summary

Session 09 Safety

Activity **09-03**

Manage Safety Process

	FTE	Cost	People Time	Activity Driver Candidates -	-	-	Production Volume -	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Provide alerts to plant about new OSHA requirements	0.0	0	0	0	0	0	0		0	0	0	0	0
2 Participate on HDC Management team	0.1	3,362	1	0	0	0	0	35	35	0	0	0	0
3 Go to meetings	0.6	23,535	7	0	0	0	0	5	2.5	0	0	0	2.5
4 Central Safety Team Participation	0.1	5,043	1.5	0	0	0	0	5	5	0	0	0	0
5 Safety training self/others	0.5	20,173	6	0	0	0	0	1	1	0	0	0	0
6 Develop company safety policy	0.0	1,681	0.5	0	0	0	0		0	0	0	0	0
7 Safety consultation	0.9	31,941	9.5	0	0	0	0	1	1	0	0	0	0
8 Issue safety permits	0.5	16,811	5	0	0	0	0	5	5	0	0	0	0
9 Plan safety celebrations	0.0	1,681	0.5	0	0	0	0		0	0	0	0	0
10 Maintain safety video library	0.0	1,681	0.5	0	0	0	0	1	1	0	0	0	0
11 Provide safety liason to various project teams	0.1	3,362	1	0	0	0	0	1	1	0	0	0	0
12 Present safety statistics in various meetings	0.1	3,362	1	0	0	0	0	10	0	0	0	0	10
13 Provide safety training materials	0.0	1,681	0.5	0	0	0	0		0	0	0	0	0
Activity Total	3.1	114,315	34	0	0	0	0						
		4,354	3.8%					3.8%	3,429	0	0	0	925

Activity **09-04**

Neutralize Explosives

	FTE	Cost	People Time	Activity Driver Candidates -	-	-	Production Volume -	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Burn waste explosives	0.2	6,724	2	0	0	0	0	100	0	0	0	100	0
2 Maintain B6 records	0.2	6,724	2	0	0	0	0	100	0	0	0	0	100
3 Decontaminate material equipment	0.2	6,724	2	0	0	0	0	20	10	0	0	10	0
4 Burn explosives conatminated waste	0.1	3,362	1	0	0	0	0	100	100	0	0	0	0
Activity Total	0.6	23,535	7	0	0	0	0						
		18,156	77.1%					77.1%	4,035	0	0	7,397	6,724

Activity **09-05**

Respond to emergencies

	FTE	Cost	People Time	Activity Driver Candidates -	-	-	Production Volume -	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Incident command/Guidance to security department	0.1	3,362	1	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 09 Safety

Task	FTE	Cost	People Time	-	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
2 Establish/coordinate command post activitive	0.5	16,811	5	0	0	0	0	19	0	0	6.33	6.33	6.34
3 Monitor weather	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.5	20,173	6	0	0	0	0						
		3,194	15.8%					15.8%	0	0	1,064	1,064	1,066

Activity **09-06**

Comply with Regulations

Activity Note

Activity Driver Candidates

Task	*FTE*	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Provide MSDS's to customers (Fax,etc)	0.0	1,681	0.5	0	0	0	0		0	0	0	0	0
2 Answer hazard communication questions in house	0.0	0	0	0	0	0	0		0	0	0	0	0
3 Prepare MSDS's for explosives (updates)	0.0	1,681	0.5	0	0	0	0	10	0	0	0	10	0
4 Review/update hazard communication program	0.1	3,362	1	0	0	0	0		0	0	0	0	0
5 Secretary for process safety review committee	0.1	3,362	1	0	0	0	0	10	10	0	0	0	0
6 Co-ordinate employee advisory panel meetings/activities	0.0	1,681	0.5	0	0	0	0		0	0	0	0	0
7 Work on process hazard analysis teams	0.2	6,724	2	0	0	0	0	10	0	0	10	0	0
Activity Total	0.5	18,492	5.5	0	0	0	0						
		1,177	6.4%					6.4%	336	0	672	168	0

Activity **09-07**

Insuring Regulatory Compliance

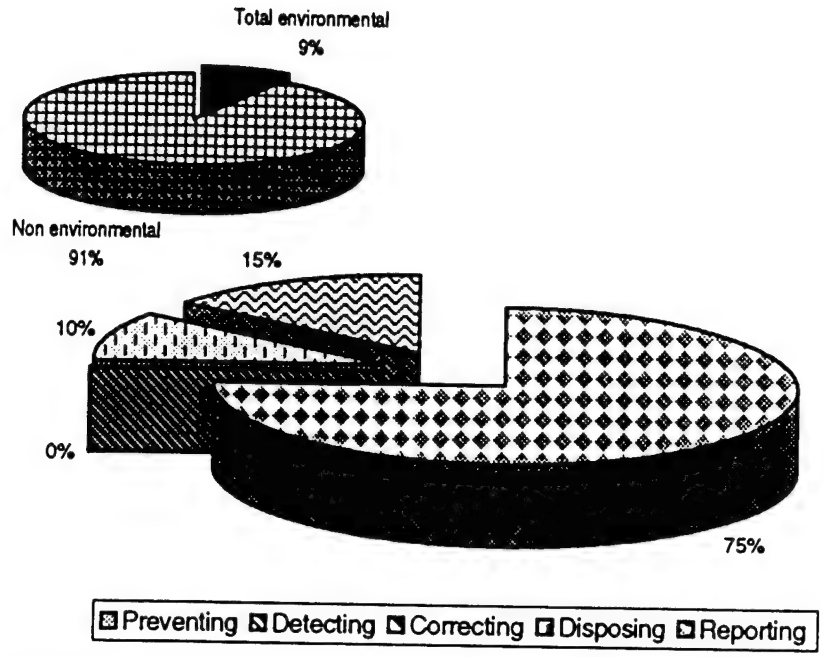
Activity Note

Activity Driver Candidates Production Volume

Task	*FTE*	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Revise plant protection standards	0.2	6,724	2	0	0	0	0		0	0	0	0	0
2 Prepare plant protection	0.0	1,681	0.5	0	0	0	0		0	0	0	0	0
3 Review process changes	0.1	5,043	1.5	0	0	0	0		0	0	0	0	0
4 Review all PPE	0.1	3,362	1	0	0	0	0	1	0.5	0	0	0.5	0
5 Writing SOP's	0.0	1,681	0.5	0	0	0	0	30	30	0	0	0	0
6 Approve SOP's	0.1	3,362	1	0	0	0	0		0	0	0	0	0
7 Approve process changes	0.0	1,681	0.5	0	0	0	0		0	0	0	0	0
8 Review inhouse and subcontractor SOW's for safety related issues	0.1	3,362	1	0	0	0	0		0	0	0	0	0
9 Review design drawing packages for facility installations, modifications	0.0	1,681	0.5	0	0	0	0		0	0	0	0	0
10 Review SOP's	0.3	10,087	3	0	0	0	0		0	0	0	0	0

Activity Total	1.0	38,665	11.5	0	0	0	0						
		538	1.4%					1.4%	521	0	0	17	0
Session Total	9.0	336,220	100	0	0	0	0						
		39,371	11.7%						12,339	2,522	3,788	8,646	12,077

Stores and Receiving



Session Number	10
Group	Stores and Receiving
Organization	Production Support

Category	Cost	% of Total	% of Environmental
Preventing	9,569	6.4%	74.8%
Detecting	-	0.0%	0.0%
Correcting	6	0.0%	0.1%
Disposing	1,286	0.9%	10.1%
Reporting	1,929	1.3%	15.1%
Total environmental	12,790	8.6%	100.0%
Non environmental	135,641	91.4%	
Cost	148,431	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
10	Stores and Receiving								
10-01	Receive Materials	208	0	0	0	0	208	49,087	0.4%
10-02	Control Stores	4,583	0	0	0	0	4,583	62,529	7.3%
10-03	Recycle Materials	64	0	0	1,286	0	1,350	12,272	11.0%
10-04	Manage Store and Receiving	79	0	0	0	0	79	14,258	0.6%
10-05	Prepare Required Reports	1,935	0	6	0	1,929	3,870	5,143	75.3%
10-06	Inspect Facilities and Equipment	2,700	0	0	0	0	2,700	5,143	52.5%
Subtotal Stores and Receiving		9,569	0	6	1,286	1,929	12,790	148,431	8.6%

Holston Activity and Task Summary

Session 10 Stores and Receiving

Date 8/4/97 — 3 Participants — Eugene White, Bob Pierce, Jerry Ward — Observers — Ennis, Glenn, Keith, Mark

Time 8:00 — FTE: — 5 85 Years Experience — Note

Activity **10-01**

Receive Materials

Activity Note

	FTE	Cost	People Time	Maintanence	Activity Driver Candidates -	-	-	Maintanence Costs Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Make Folders	0.2	5,143	2	0	0	0	0		0	0	0	0	0
2 Check For New Purchase Orders on Comp from Previous Day	0.2	5,143	2	0	0	0	0		0	0	0	0	0
3 Receive Items Per Receiving ReportSpec. Make Copies for each Dept. Needing Docs.	0.5	14,258	6	2	0	0	0	1	1	0	0	0	0
4 Materials Must Then Be Delivered by Personnel to Requisitioner	0.3	6,544	3	2	0	0	0	1	1	0	0	0	0
5 Check for Orders Being Held	0.0	1,286	0.5	0	0	0	0		0	0	0	0	0
6 Call Purchasing About Orders We Have w/out Paperwork	0.1	2,571	1	0	0	0	0		0	0	0	0	0
7 Ship Freight Back to Vendor When Received In Error or Overage	0.1	3,857	1.5	0	0	0	0		0	0	0	0	0
8 Verify All HOL Property and Assign Numbers for Needful RR's	0.1	2,571	1	0	0	0	0		0	0	0	0	0
9 Update Computer Files on Items Received Each Day	0.3	7,714	3	0	0	0	0		0	0	0	0	0
Activity Total	1.7	49,087	20	4	0	0	0						
		208	0.4%	1.0%				0.4%	208	0	0	0	0

Activity **10-02**

Control Stores

Activity Note

	FTE	Cost	People Time	Maintanence	Activity Driver Candidates -	-	-	Maintanence Cost Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Setup/Maintain Stores Purchasing Authority	0.1	2,571	1	0	0	0	0		0	0	0	0	0
2 Request Materials	0.0	1,286	0.5	0	0	0	0	1	1	0	0	0	0
3 Stock Materials	0.2	4,558	2	1	0	0	0	10	10	0	0	0	0
4 Inventory Materials	0.1	2,571	1	0	0	0	0		0	0	0	0	0
5 Control Inventory	0.1	2,571	1	0	0	0	0		0	0	0	0	0
6 Transfer Materials	0.0	1,286	0.5	0	0	0	0		0	0	0	0	0
7 Issue Materials	1.3	41,142	16	0	0	0	0	10	10	0	0	0	0
8 Reconcile Records	0.1	2,571	1	0	0	0	0		0	0	0	0	0
9 Update Description Files	0.0	1,286	0.5	0	0	0	0		0	0	0	0	0
10 Check Conputer Activity	0.0	1,286	0.5	0	0	0	0		0	0	0	0	0
11 Purge Records After 2 Years	0.0	1,286	0.5	0	0	0	0		0	0	0	0	0
12 Write Work Orders for Fabrication	0.0	116	0.5	2	0	0	0		0	0	0	0	0

	FTE	Cost	People Time	Maintane nce	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
Activity Total	2.1	62,529	25	3	0	0	0						
		4,583	7.2%	3.3%				7.3%	4,583	0	0	0	0

Activity **10-03**

Recycle Materials

Activity Note

Activity Driver Candidates Maintanence Cost

	FTE	Cost	People Time	Maintane nce	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Maintain Salvage Records	0.0	1,286	0.5	0	0	0	0	5	5	0	0	0	0
2 Weigh Scrap	0.0	701	0.5	1	0	0	0		0	0	0	0	0
3 Excess Materials Sales	0.2	5,143	2	0	0	0	0		0	0	0	0	0
5 Recycle Clothinng to Rags	0.1	2,571	1	0	0	0	0		0	0	0	0	0
8 Prepare Disposal Requests	0.0	1,286	0.5	0	0	0	0	100	0	0	0	100	0
9 Recycle Paper	0.0	1,286	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.4	12,272	5	1	0	0	0						
		1,350	10.5%	0.0%				11.0%	64	0	0	1,286	0

Activity **10-04**

Manage Store and Receiving

Activity Note

Activity Driver Candidates N/A Facility Sustaining

	FTE	Cost	People Time	Maintane nce	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Check Personnel	0.0	1,286	0.5	0	0	0	0		0	0	0	0	0
2 Conduct Meetings-Safety, Inventory Control, & Project Completion	0.1	2,571	1	0	0	0	0	1	1	0	0	0	0
3 Check E-mail	0.0	1,286	0.5	0	0	0	0		0	0	0	0	0
4 Check Voice Mail	0.0	0	0	0	0	0	0		0	0	0	0	0
5 Write Work Orders for Maintanence	0.0	116	0.5	2	0	0	0	2	2	0	0	0	0
6 Attend Management Meetings	0.1	2,571	1	0	0	0	0		0	0	0	0	0
7 Conduct Mandatory Training	0.0	1,286	0.5	0	0	0	0	1	1	0	0	0	0
8 Attend Training Sessions	0.1	3,857	1.5	0	0	0	0	1	1	0	0	0	0
9 Check Time Keeper	0.0	1,286	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.5	14,258	6	2	0	0	0						
		79	0.7%	2.0%				0.6%	79	0	0	0	0

Activity **10-05**

Prepare Required Reports

Activity Note

Activity Driver Candidates N/A Regulatory

	FTE	Cost	People Time	Maintane nce	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 SPCC Plans-Write, Review, Update	0.0	1,286	0.5	0	0	0	0	100	100	0	0	0	0
2 SARA 312, 313 Reports	0.0	1,286	0.5	0	0	0	0	100	0	0	0	0	100

Holston Activity and Task Summary

Session 10 Stores and Receiving

3 Update MSDS Files	0.0	1,286	0.5	0	0	0	0	100	50	0	0	0	50
4 Gather MSDS Sheets When Accompaning Material, Then Send MSDS Sheets to Safety	0.0	0	0	0	0	0	0		0	0	0	0	0
5 Accidents and Spill Reviews	0.0	1,286	0.5	0	0	0	0	1	0.5	0	0.5	0	0
Activity Total	0.2	5,143	2	0	0	0	0						
		3,870	75.2%					75.3%	1,935	0	6	0	1,929

Activity **10-06**

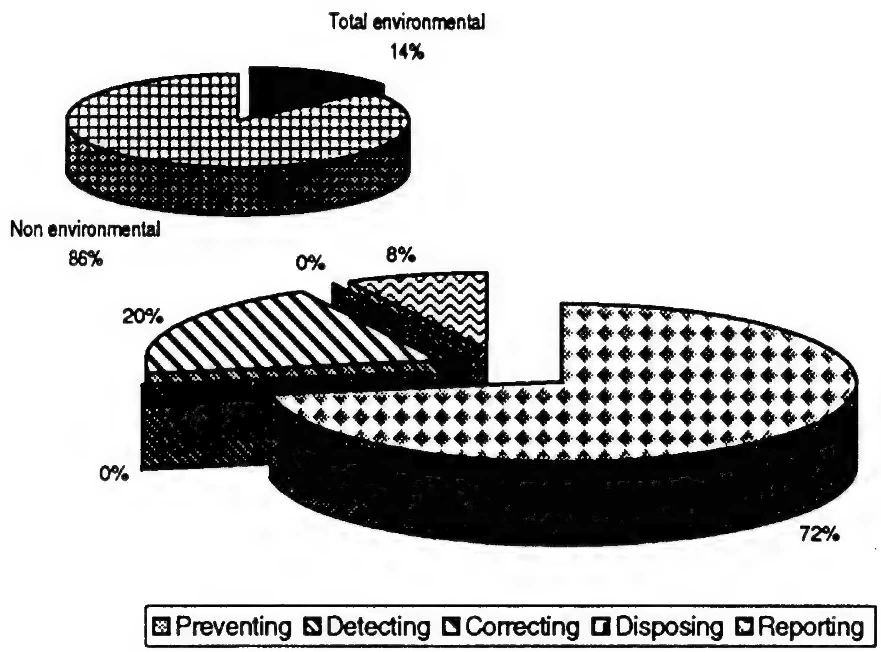
Inspect Facilities and Equipment

Activity Note

Activity Driver Candidates N/A Regulatory and Facility

	FTE	Cost	People Time	Maintanence	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 nspect Hazardous Materials Storage Location	0.0	1,286	0.5	0	0	0	0	100	100	0	0	0	0
2 Environmental Inspection	0.0	1,286	0.5	0	0	0	0	100	100	0	0	0	0
3 Inspect Buildings Daily	0.1	2,571	1	0	0	0	0	5	5	0	0	0	0
4 Inspect Containers Pipes Etc.	0.0	0	0	0	0	0	0	100	100	0	0	0	0
Activity Total	0.2	5,143	2	0	0	0	0						
		2,700	52.5%					52.5%	2,700	0	0	0	0
Session Total	5.0	148,431	60	10	0	0	0						
		12,790	8.4%	1.8%					9,569	0	6	1,286	1,929

Security, Fire, Emergency



Session Number	11		
Group	Security, Fire, Emergency		
Organization	Support		

Category	Cost	% of Total	% of Environmental
Preventing	102,861	10.2%	72.4%
Detecting	-	0.0%	0.0%
Correcting	28,227	2.8%	19.9%
Disposing	23	0.0%	0.0%
Reporting	10,886	1.1%	7.7%
Total environmental	141,997	14.1%	100.0%
Non environmental	862,004	85.9%	
Cost	1,004,002	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
11	Security, Fire, Emergency								
11-01	Manage Operations	3,030	0	23	23	319	3,396	230,513	1.5%
11-02	Secure Facilities	76,055	0	3,026	0	0	79,081	433,737	18.2%
11-03	Report Activities	0	0	0	0	10,567	10,567	74,664	14.2%
11-04	Respond to Emergency	0	0	25,177	0	0	25,177	39,440	63.8%
11-05	Maintain Fire Protection Equipment	0	0	0	0	0	0	70,448	0.0%
11-06	Inspect Facilities and Equipment	5,812	0	0	0	0	5,812	84,751	6.9%
11-07	Train Personnel	17,964	0	0	0	0	17,964	70,448	25.5%
Subtotal Security, Fire, Emergency		102,861	0	28,227	23	10,886	141,997	1,004,002	14.1%

Holston Activity and Task Summary

Session 11 Security, Fire, Emergency

Date 8/4/97 3 Participants Jim Stallard, Gene Faxon, Richard Mann Observers Ennis, Glenn, Keith, Mark

Time 1:00 FTE: 5 53 Years Experience Note

Activity **11-01**

Manage Operations

	FTE	Cost	People Time	Subcontr acting-	Subcontr acting-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
			Activity Note										
			Activity Driver Candidates				Facility						
1 Plan Budget	0.5	4,655	1	0	0	0	0	1	0	0	0.5	0.5	0
2 Admin Contract for Emergency Equipment	0.5	4,655	1	0	0	0	0	40	40	0	0	0	0
3 Write Funding Douments	0.5	4,655	1	0	0	0	0		0	0	0	0	0
4 Administrative Responsibility	0.5	58,398	1	3	2	0	0	2	2	0	0	0	0
6 Support Board/Officer of Company	0.0	0	0	0	0	0	0		0	0	0	0	0
7 Write Work Orders for Security Support Facilities	1.0	9,310	2	0	0	0	0		0	0	0	0	0
8 Submit Reqest for Equipment Replacement	0.0	0	0	0	0	0	0		0	0	0	0	0
10 Review and Edit Standard Procedures	0.5	4,655	1	0	0	0	0		0	0	0	0	0
12 Respond to Request for Admin Building Support	0.0	0	0	0	0	0	0		0	0	0	0	0
13 Respond to Telcon	0.0	10,087	0	1	0	0	0		0	0	0	0	0
14 Respond to Unusual Events	0.0	26,044	0	2	0.5	0	0		0	0	0	0	0
15 Write Work Orders for Fire Protection Equipment	0.5	4,655	1	0	0	0	0		0	0	0	0	0
16 Provide Communication System Radio	0.0	0	0	0	0	0	0		0	0	0	0	0
17 Log Admin Info in Personnel Files	0.0	31,915	0	2	1	0	0	1	0	0	0	0	1
18 Ensure Compliance with Contract	0.5	4,655	1	0	0	0	0		0	0	0	0	0
19 Review AMC, NFPA, Army, Local Regulations	0.0	5,871	0	0	0.5	0	0		0	0	0	0	0
20 Review Projects/Equipment Needs, Report to Contract Administration	0.0	10,087	0	1	0	0	0		0	0	0	0	0
21 Meet With Mutual Aid Providers Regularly	0.0	0	0	0	0	0	0		0	0	0	0	0
22 Respond, React to Reports	0.5	24,829	1	2	0	0	0		0	0	0	0	0
23 Meet with Shift Captains on Projects/Activities	0.0	15,958	0	1	0.5	0	0		0	0	0	0	0
24 Meet with Contractor on Special Needs/Projects	0.0	10,087	0	1	0	0	0		0	0	0	0	0
Activity Total	5.0	230,513	10	13	4.5	0	0						
		3,396	4.3%	0.6%	1.1%			1.5%	3,030	0	23	23	319

Holston Activity and Task Summary

Session 11 Security, Fire, Emergency

Activity **11-02**

Secure Facilities

Activity Note

Activity Driver Candidates: Facility(May Increase w/ Noticable Jump in Prodcution)

		FTE	Cost	People Time	Subcontr acting-	Subcontr acting-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1	Issue of Badges	0.0	20,174	0	2	0	0	0		0	0	0	0	0
2	Security Shift Supervisor at Command Post	0.0	10,087	0	1	0	0	0		0	0	0	0	0
4	Perform Security Checks of Inactive Bldgs	0.0	0	0	0	0	0	0		0	0	0	0	0
5	Check of A to B Pipeline	0.0	20,174	0	2	0	0	0	100	100	0	0	0	0
6	Project Safety Managment Training	0.0	20,174	0	2	0	0	0	2	2	0	0	0	0
7	Annual Security Training to Include Firearms	0.0	40,348	0	4	0	0	0		0	0	0	0	0
8	Traffic Enforcement	0.0	10,087	0	1	0	0	0		0	0	0	0	0
9	Security Patrols	0.0	221,912	0	22	0	0	0	25	25	0	0	0	0
10	Establish Site Security for Events	0.0	0	0	0	0	0	0		0	0	0	0	0
11	Provide Lock and Key Function	0.0	10,087	0	1	0	0	0		0	0	0	0	0
12	Operate Switchboard	0.0	20,174	0	2	0	0	0		0	0	0	0	0
13	Plant Dispatch (911)	0.0	60,521	0	6	0	0	0	5	0	0	5	0	0
	Activity Total	0.0	433,737	0	43	0	0	0						
			79,081		18.2%				18.2%	76,055	0	3,026	0	0

Activity **11-03**

Report Activities

Activity Note

Activity Driver Candidates: Production

		FTE	Cost	People Time	Subcontr acting-	Subcontr acting-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1	Reports on Runs	0.0	11,741	0	0	1	0	0		0	0	0	0	0
2	Daily Radio Log Report	0.0	21,828	0	1	1	0	0		0	0	0	0	0
3	Complete Fire/Spill Reports on Major Incidents	0.0	11,741	0	0	1	0	0	90	0	0	0	0	90
4	Check Pass-on From Previous Shift	0.0	5,871	0	0	0.5	0	0		0	0	0	0	0
5	Review Morning Reports	0.0	11,741	0	0	1	0	0		0	0	0	0	0
6	Monitor Deficiency/Correction Reports	0.0	0	0	0	0	0	0		0	0	0	0	0
7	Deliver Reports to Project Management & Contract Administration	0.0	0	0	0	0	0	0		0	0	0	0	0
9	Complete Monthly/Annual Progress Reports	0.0	11,741	0	0	1	0	0		0	0	0	0	0
	Activity Total	0.0	74,664	0	1	5.5	0	0						
			10,567		0.0%	16.4%			14.2%	0	0	0	0	10,567

Holston Activity and Task Summary

Session 11 Security, Fire, Emergency

Activity 11-04
Respond to Emergency

Activity Note

	FTE	Cost	People Time	Subcontr acting-	Subcontr acting-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
			Activity Driver Candidates			Production							
1 Spills-EMS-Fire Prevention	0.0	33,570	0	1	2	0	0	75	0	0	75	0	0
2 Confined Space Function	0.0	5,871	0	0	0.5	0	0		0	0	0	0	0
4 Participate in Community Safety Organization	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.0	39,440	0	1	2.5	0	0						
		25,177		75.0%	60.0%			63.8%	0	0	25,177	0	0

Activity 11-05
Maintain Fire Protection Equipment

Activity Note

	FTE	Cost	People Time	Subcontr acting-	Subcontr acting-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
			Activity Driver Candidates			Production							
1 Sprinkler Maintanence	0.0	35,224	0	0	3	0	0		0	0	0	0	0
2 Fire Prevention	0.0	23,483	0	0	2	0	0		0	0	0	0	0
3 Maintain Fire Hydrants	0.0	11,741	0	0	1	0	0		0	0	0	0	0
Activity Total	0.0	70,448	0	0	6	0	0						
		0			0.0%			0.0%	0	0	0	0	0

Activity 11-06
Inspect Facilities and Equipment

Activity Note

	FTE	Cost	People Time	Subcontr acting-	Subcontr acting-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
			Activity Driver Candidates			Production							
1 Audits/Inspections	0.0	26,044	0	2	0.5	0	0		0	0	0	0	0
2 Fuel Storage Inspections	0.0	5,871	0	0	0.5	0	0	99	99	0	0	0	0
3 Fire Prevention Inspections of Buildings	0.0	35,224	0	0	3	0	0		0	0	0	0	0
4 Equipment Check	0.0	11,741	0	0	1	0	0		0	0	0	0	0
5 Check PH Monitors	0.0	0	0	0	0	0	0		0	0	0	0	0
7 Communicate Inspection Deficiencies to Bldg Supervisors	0.0	5,871	0	0	0.5	0	0		0	0	0	0	0
Activity Total	0.0	84,751	0	2	5.5	0	0						
		5,812		0.0%	9.0%			6.9%	5,812	0	0	0	0

Activity 11-07
Train Personnel

Activity Note

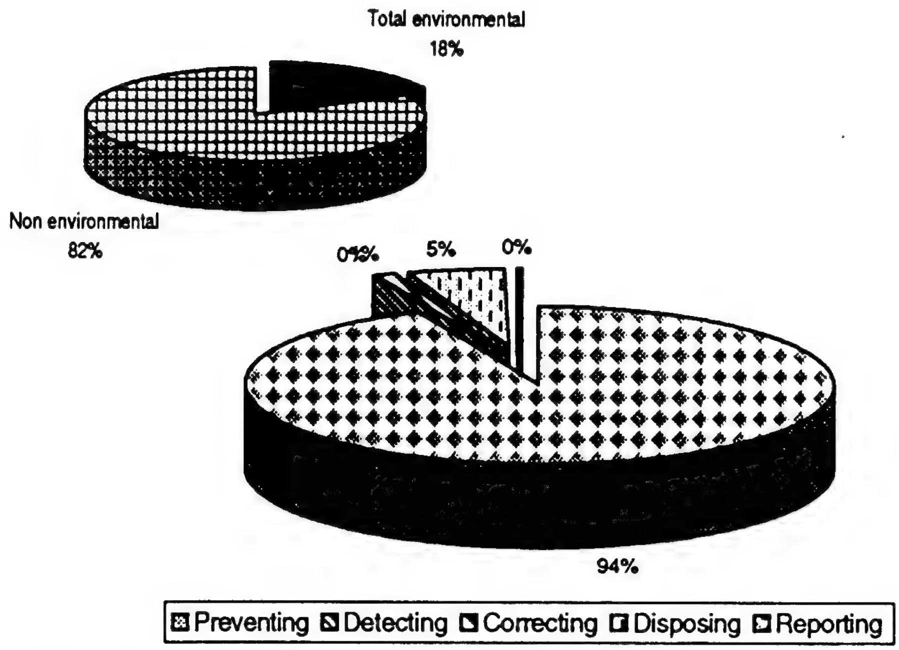
	FTE	Cost	People Time	Subcontr acting-	Subcontr acting-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
			Activity Driver Candidates			Facility							
1 Physical Training	0.0	5,871	0	0	0.5	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 11 Security, Fire, Emergency

2 Dept. Training	0.0	35,224	0	0	3	0	0	50	50	0	0	0	0
3 Present Training	0.0	11,741	0	0	1	0	0		0	0	0	0	0
4 Training Records	0.0	17,612	0	0	1.5	0	0	2	2	0	0	0	0
Activity Total	0.0	70,448	0	0	6	0	0						
		17,964			25.5%			25.5%	17,964	0	0	0	0
Session Total	5.0	1,004,002	10	60	30	0	0						
		141,997	4.3%	14.4%	14.9%				102,861	0	28,227	23	10,886

Area B Acids



Session Number	12	
Group	Area B Acids	
Organization	Production Support	

Category	Cost	% of Total	% of Environmental
Preventing	156,299	16.7%	93.4%
Detecting	-	0.0%	0.0%
Correcting	1,528	0.2%	0.9%
Disposing	9,170	1.0%	5.5%
Reporting	357	0.0%	0.2%
Total environmental	167,353	17.9%	100.0%
Non environmental	769,843	82.1%	
Cost	937,197	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
12	Area B Acids								
12-01	Manage Operations	32,633	0	1,528	815	357	35,333	220,067	16.1%
12-02	Conduct Training	8,151	0	0	204	0	8,355	36,679	22.8%
12-03	Produce Nitric Acid/Ammonium Nitrate	72,730	0	0	0	0	72,730	366,694	19.8%
12-04	Recover Acetic Acid	42,785	0	0	8,151	0	50,936	313,756	16.2%
Subtotal Area B Acids		156,299	0	1,528	9,170	357	167,353	937,197	17.9%

Holston Activity and Task Summary

Session 12 Area B Acids

Date	8/5/97	3 Participants	Jerry Blair, Dean Tolley, Pat Simpson	Observers	Ennis, Glenn, Keith, Mark
Time	8:00	FTE:	20 103 Years Experience	Note	

Activity **12-01**

Manage Operations

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	Maintanence	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Turn on Computers, Read Messages, Etc.	0.3	12,226	3	0	0	0	0		0	0	0	0	0
2 Plan Operations with Operators	0.9	32,604	8	0	0	0	0	10	10	0	0	0	0
3 Check Messages/ Talk W/ Shift Team Member	0.1	4,075	1	0	0	0	0	2	2	0	0	0	0
4 Shift Turnover	0.2	8,151	2	0	0	0	0	30	30	0	0	0	0
5 Plan, Staffing, Etc.	0.2	8,151	2	0	0	0	0		0	0	0	0	0
6 Keep Time Records	0.2	8,151	2	0	0	0	0		0	0	0	0	0
7 Solve or Get Solved Technical Questions	0.3	12,226	3	0	0	0	0	30	30	0	0	0	0
8 Monday Morning Meeting w/ Dept. Head and Maintanence	0.1	4,075	1	0	0	0	0	20	20	0	0	0	0
9 Answer Phone Calls	0.4	16,302	4	0	0	0	0	10	5	0	0	5	0
10 Check and Sign all Safety Permits	0.1	4,075	1	0	0	0	0	5	5	0	0	0	0
11 Attend Meetings	0.4	14,264	3.5	0	0	0	0	10	7.5	0	0	0	2.5
12 Talk Over Operation w/ Dept. Head	0.4	16,302	4	0	0	0	0	5	5	0	0	0	0
13 Prepare/Revise SPCC Plans	0.2	8,151	2	0	0	0	0	100	100	0	0	0	0
14 Keep Production Inventories	0.4	16,302	4	0	0	0	0		0	0	0	0	0
15 Answer Questions, Participate in Making Decisions	0.3	12,226	3	0	0	0	0	20	20	0	0	0	0
16 Prepare/Revise Operating Documents	0.2	8,151	2	0	0	0	0	20	20	0	0	0	0
17 Investigate Accidental Discharges, Accidents, etc.	0.2	6,113	1.5	0	0	0	0	50	25	0	25	0	0
18 Plan Maint w/ Maint Manager	0.4	28,518	4	3	0	0	0	20	20	0	0	0	0
Activity Total	5.7	220,067	51	3	0	0	0						
		35,333	15.8%	20.0%				16.1%	32,633	0	1,528	815	357

Activity **12-02**

Conduct Training

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	Maintanence	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Certify Operators Every 3 Years	0.2	8,151	2	0	0	0	0	20	20	0	0	0	0
2 Training on Spreadsheets	0.1	4,075	1	0	0	0	0	100	100	0	0	0	0
3 MSDS, Other Technical Information	0.1	4,075	1	0	0	0	0	10	5	0	0	5	0
4 Keep Training Records	0.1	4,075	1	0	0	0	0	20	20	0	0	0	0

5 Hold Safety Meetings w/ Operators Every 4 Weeks	0.1	4,075	1	0	0	0	0	25	25	0	0	0	0
6 Once a Month Training on Different Aspect of Safety Procedure	0.1	4,075	1	0	0	0	0		0	0	0	0	0
7 Cross-Training w/ Other Operators	0.1	4,075	1	0	0	0	0	10	10	0	0	0	0
8 ATAIM Safety Meeting. Keep Up w/ SOP Procedure	0.1	4,075	1	0	0	0	0		0	0	0	0	0
Activity Total	1.0	36,679	9	0	0	0	0						
		8,355	22.8%					22.8%	8,151	0	0	204	0

Activity **12-03**

Produce Nitric Acid/Ammonium Nitrate

Activity Note

			Activity Driver Candidates					Production Volume					
	FTE	Cost	People Time	Maintanence	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Unloading/Degassing NH3 Cars	0.3	12,226	3	0	0	0	0	10	10	0	0	0	0
2 Acid Operator Change Clothes/Shift Change	0.1	4,075	1	0	0	0	0		0	0	0	0	0
3 Scrubber for 503/504 tanks	0.0	0	0	0	0	0	0		0	0	0	0	0
4 Change Platinum Gauze	0.0	12,216	0	3	0	0	0		0	0	0	0	0
5 Extended Absorber 302B	0.0	4,072	0	1	0	0	0	100	100	0	0	0	0
6 Check Bldg-Get Reading, Get Samples	0.1	4,075	1	0	0	0	0		0	0	0	0	0
7 Check All Down Bldgs Several Times Each Shift	0.9	32,604	8	0	0	0	0	50	50	0	0	0	0
8 Make 60% Nitric	1.3	73,339	12	6	0	0	0	10	10	0	0	0	0
9 Receive Mag Oxide	0.0	0	0	0	0	0	0		0	0	0	0	0
10 Scrubber for Storage Tanks 99%	0.0	0	0	0	0	0	0		0	0	0	0	0
11 Make 99% Nitric	2.9	150,757	26	11	0	0	0	25	25	0	0	0	0
12 Prepare Mag Nitrate	0.1	4,075	1	0	0	0	0		0	0	0	0	0
13 Run Unit Check 99%/Run Lab Standard on 503/504	0.2	8,151	2	0	0	0	0		0	0	0	0	0
14 Spent Mag NO4 to Landfill	0.0	0	0	0	0	0	0		0	0	0	0	0
15 Storing Soda Ash in Bldg's	0.0	0	0	0	0	0	0		0	0	0	0	0
16 Make Ammonium Nitrate 503/504	0.7	44,814	6	5	0	0	0	10	10	0	0	0	0
17 Pump 503/504 to Explosives Plant	0.0	16,289	0	4	0	0	0	10	10	0	0	0	0
Activity Total	6.7	366,694	60	30	0	0	0						
		72,730	21.0%	17.5%				19.8%	72,730	0	0	0	0

Activity **12-04**

Recover Acetic Acid

Activity Note

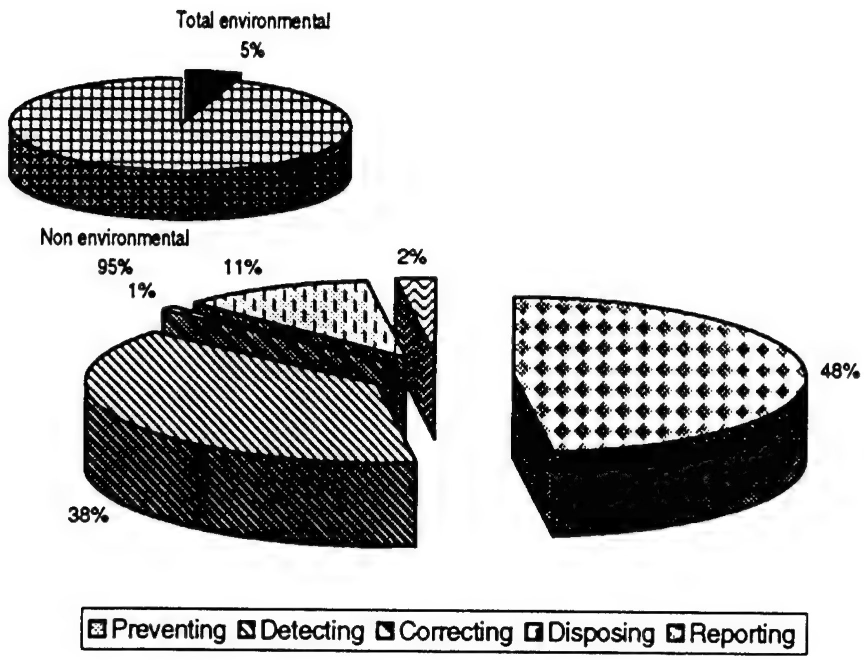
			Activity Driver Candidates					Production Batches					
	FTE	Cost	People Time	Maintanence	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting

Holston Activity and Task Summary

Session 12 Area B Acids

1 Process Monthly Inventory and Samples	0.1	2,038	0.5	0	0	0	0		0	0	0	0	0
2 Change Into Operating Clothes as Use in the Operation	0.0	0	0	0	0	0	0		0	0	0	0	0
3 Make Ready for Maint Work and Safety to Perform Work	0.0	0	0	0	0	0	0		0	0	0	0	0
4 Check Equipment Getting Readings on Operating Units Check on Acid to be Process	0.7	52,958	6	7	0	0	0	15	15	0	0	0	0
5 Shift Turnover	0.0	0	0	0	0	0	0		0	0	0	0	0
6 Do Monthly and Weekly Safety Checks	0.0	0	0	0	0	0	0		0	0	0	0	0
7 Receiveing Acetic Acids from Explosives	0.2	8,151	2	0	0	0	0	5	5	0	0	0	0
8 NH3 is Stored in Tank 11&12 to Neutralize Acetic Acid	0.1	12,220	1	2	0	0	0		0	0	0	0	0
9 Run Samples on Units That Are Operating	0.2	8,151	2	0	0	0	0		0	0	0	0	0
10 Collect Samples	0.3	10,189	2.5	0	0	0	0	2	2	0	0	0	0
11 B Line Process to Recover Acetic Acid	3.3	142,626	30	5	0	0	0	20	20	0	0	0	0
12 Process Final Sludge to Produce ANg. 77	0.4	16,302	4	0	0	0	0	50	0	0	0	50	0
13 Receive NH3 for B line	0.1	2,038	0.5	0	0	0	0	10	10	0	0	0	0
14 Recover Acetic Acid 506 Slurry	0.0	0	0	0	0	0	0		0	0	0	0	0
15 ANg 77 is Stored at Bldg B5 to be Processed in Batches for Shipment	0.0	4,072	0	1	0	0	0		0	0	0	0	0
16 Nitrates to Watse Water Due to Operating Ahg Operation	0.0	0	0	0	0	0	0		0	0	0	0	0
17 Wet Scrubber on Prodct Tasks A	0.0	0	0	0	0	0	0		0	0	0	0	0
18 Load Tank Trucks W/ ANg 77	0.2	6,113	1.5	0	0	0	0	10	10	0	0	0	0
19 Transfer 525 from B3 to B7 Tank Farm	0.6	20,377	5	0	0	0	0	10	10	0	0	0	0
20 Transfer 525 to Area A	0.4	18,336	3.5	1	0	0	0	10	10	0	0	0	0
21 Transfer 506 Slurry to Explosives	0.2	10,185	1.5	1	0	0	0	10	10	0	0	0	0
Activity Total	6.7	313,756	60	17	0	0	0						
		50,936	17.1%	13.2%				16.2%	42,785	0	0	8,151	0
Session Total	20.0	937,197	180	50	0	0	0						
		167,353	18.3%	16.2%					156,299	0	1,528	9,170	357

Development/Quality Assurance



Session Number	13
Group	Development/Quality Assurance
Organization	Support

Category	Cost	% of Total	% of Environmental
Preventing	19,090	2.6%	47.8%
Detecting	15,301	2.1%	38.3%
Correcting	291	0.0%	0.7%
Disposing	4,372	0.6%	10.9%
Reporting	874	0.1%	2.2%
Total environmental	39,929	5.4%	100.0%
Non environmental	706,187	94.6%	
Cost	746,116	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
13	Development/Quality Assurance								
13-01	Providing Technical Support	3,352	4,226	0	0	0	7,578	119,495	6.3%
13-02	Develop/Update Analytical Methods	0	7,578	0	0	0	7,578	104,923	7.2%
13-03	Train Personnel	0	0	0	0	0	0	17,487	0.0%
13-04	Provide Administrative Support	291	291	291	291	0	1,166	49,547	2.4%
13-05	Assure Product Quality	1,312	0	0	0	0	1,312	288,537	0.5%
13-06	Analyze Samples	0	1,457	0	2,915	0	4,372	46,632	9.4%
13-07	Develop Products/Prcesses	14,135	1,749	0	1,166	874	17,924	119,495	15.0%
Subtotal Development/Quality Assurance		19,090	15,301	291	4,372	874	39,929	746,116	5.4%

Holston Activity and Task Summary

Session 13 Development/Quality Assurance

Date 8/5/97 | 5 Participants | Sharon Bacon-Fife, Charlie Brumley, Bill Bullis, Ervin, Charlie Smith | Observers | Ennis, Glenn, Keith, Mark

Time 1:00 | FTE: | 13 117 Years Experience | Note

Activity **13-01**

Providing Technical Support

Activity Note: Activity Driver Candidates; Production Volume

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Analytical Troubleshooting/Instrument, Equip Problems	0.4	23,316	4	0	0	0	0		0	0	0	0	0
2 Production Problems	0.6	32,060	5.5	0	0	0	0	10	10	0	0	0	0
3 Evaluate External Research on Request	0.0	0	0	0	0	0	0		0	0	0	0	0
4 Safety-Contaminate ID, Collect Data as Part of Accident Review, etc.	0.2	8,744	1.5	0	0	0	0	5	0	5	0	0	0
5 Administrative Questions	0.1	2,915	0.5	0	0	0	0	5	5	0	0	0	0
7 Unknown Sample Identification	0.2	8,744	1.5	0	0	0	0	10	0	10	0	0	0
8 Special Sample Analysis Requiring Chemist Expertise, Level 1	0.5	29,145	5	0	0	0	0	10	0	10	0	0	0
9 Customer Service	0.2	11,658	2	0	0	0	0		0	0	0	0	0
10 Material Compatability	0.1	2,915	0.5	0	0	0	0		0	0	0	0	0
11 Pilot Plant Operations/Support	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	2.1	119,495	20.5	0	0	0	0						
		7,578	6.3%					6.3%	3,352	4,226	0	0	0

Activity **13-02**

Develop/Update Analytical Methods

Activity Note: Activity Driver Candidates

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Methods Development for New Product, Apply New Tech to Existing Products	0.2	11,658	2	0	0	0	0	10	0	10	0	0	0
2 Half-Blinds Establish Control Limits	0.5	29,145	5	0	0	0	0		0	0	0	0	0
3 Analytical Standards Methods Development Review	1.1	64,119	11	0	0	0	0	10	0	10	0	0	0
Activity Total	1.8	104,923	18	0	0	0	0						
		7,578	7.2%					7.2%	0	7,578	0	0	0

Activity **13-03**

Train Personnel

Activity Note: Activity Driver Candidates

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Training Provided to Lab Analysts	0.3	14,573	2.5	0	0	0	0		0	0	0	0	0

Task	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
2 Attendance of Technical Meetings (External to HDC)	0.1	2,915	0.5	0	0	0	0		0	0	0	0	0
3 Safety Meetings	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.3	17,487	3	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **13-04**

Provide Administrative Support

Activity Note: Activity Driver Candidates

Task	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Turn on the Computer	0.0	0	0	0	0	0	0		0	0	0	0	0
2 Organize Schedule	0.1	5,829	1	0	0	0	0		0	0	0	0	0
3 Maintaining/Coordinating of D&C Service Contracts	0.0	0	0	0	0	0	0		0	0	0	0	0
4 Meetings/Discuss Project Plans	0.4	23,316	4	0	0	0	0	5	1.25	1.25	1.25	1.25	0
5 Review Process Changes/SOP's, etc.	0.1	5,829	1	0	0	0	0		0	0	0	0	0
6 Equipment Evaluation and Procurement	0.1	2,915	0.5	0	0	0	0		0	0	0	0	0
7 Product Support & Egineer Requirement Support (Major Equip Findings)	0.1	2,915	0.5	0	0	0	0		0	0	0	0	0
8 Maintain Time Records	0.1	2,915	0.5	0	0	0	0		0	0	0	0	0
9 Document Control (ASM, SOP, etc.)	0.1	5,829	1	0	0	0	0		0	0	0	0	0
Activity Total	0.9	49,547	8.5	0	0	0	0						
		1,166	2.4%					2.4%	291	291	291	291	0

Activity **13-05**

Assure Product Quality

Activity Note: Activity Driver Candidates Production Volume

Task	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Preparation/Revision of QA Control Documents	0.3	17,487	3	0	0	0	0		0	0	0	0	0
2 Outside Customer Support	0.3	14,573	2.5	0	0	0	0		0	0	0	0	0
3 Merging Lab & Production Data on Computer	0.2	11,658	2	0	0	0	0		0	0	0	0	0
4 Process Audits	0.4	20,402	3.5	0	0	0	0		0	0	0	0	0
5 Inspections	0.3	17,487	3	0	0	0	0		0	0	0	0	0
6 Vendor Audits	0.1	2,915	0.5	0	0	0	0		0	0	0	0	0
7 Review of Specifications	0.2	11,658	2	0	0	0	0		0	0	0	0	0
8 Nonconforming Reports	0.1	2,915	0.5	0	0	0	0		0	0	0	0	0
9 Calibrations	0.5	26,231	4.5	0	0	0	0	5	5	0	0	0	0
10 Finish Product Audits	1.7	96,179	16.5	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 13 Development/Quality Assurance

Task	FTE	Cost	People Time	-	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
11 213R(Product Cert.) Preparation	0.9	52,461	9	0	0	0	0		0	0	0	0	0
12 Raw Material Acceptance	0.3	14,573	2.5	0	0	0	0		0	0	0	0	0
Activity Total	5.0	288,537	49.5	0	0	0	0						
		1,312	0.5%					0.5%	1,312	0	0	0	0

Activity **13-06**

Analyze Samples

Activity Note

Activity Driver Candidates # of Batches

Task	*FTE*	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Prepare Samples for Analysis	0.2	11,658	2	0	0	0	0		0	0	0	0	0
2 Analyze Sample	0.5	29,145	5	0	0	0	0	5	0	5	0	0	0
3 Report Results	0.1	2,915	0.5	0	0	0	0		0	0	0	0	0
4 Dispose Samples	0.1	2,915	0.5	0	0	0	0	100	0	0	0	100	0
Activity Total	0.8	46,632	8	0	0	0	0						
		4,372	9.4%					9.4%	0	1,457	0	2,915	0

Activity **13-07**

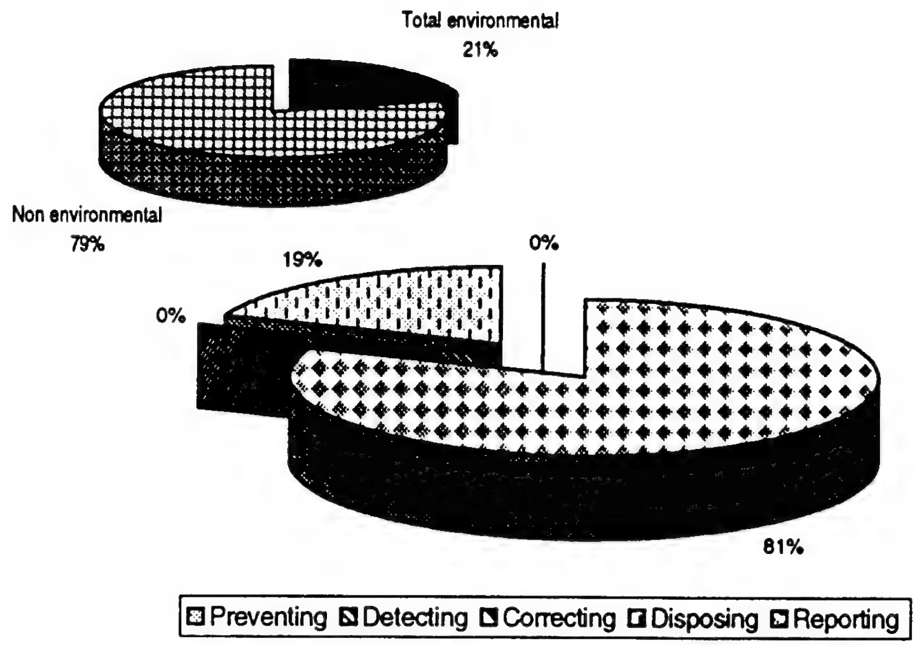
Develop Products/Prcesses

Activity Note

Activity Driver Candidates Available Funding

Task	*FTE*	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Develop & Scale Lab Processes to Production Scale	0.5	29,145	5	0	0	0	0	20	20	0	0	0	0
2 New Product Development	0.4	23,316	4	0	0	0	0	20	20	0	0	0	0
3 Technical Memos (Report)	0.2	11,658	2	0	0	0	0	10	10	0	0	0	0
4 HAZOP Studies	0.2	11,658	2	0	0	0	0		0	0	0	0	0
5 Chemical Synthesis (New)	0.2	11,658	2	0	0	0	0	30	15	15	0	0	0
6 Final Engineering Reports	0.2	8,744	1.5	0	0	0	0	10	0	0	0	0	10
7 Project Cost Estimates	0.2	8,744	1.5	0	0	0	0	5	0	0	0	5	0
8 Project Feasability Studies	0.3	14,573	2.5	0	0	0	0	10	5	0	0	5	0
Activity Total	2.1	119,495	20.5	0	0	0	0						
		17,924	15.0%					15.0%	14,135	1,749	0	1,166	874
Session Total	13.0	746,116	128	0	0	0	0						
		39,929	5.4%						19,090	15,301	291	4,372	874

Building Maintenence



Session Number	14
Group	Building Maintenence
Organization	Maintenance

Category	Cost	% of Total	% of Environmental
Preventing	37,093	16.6%	80.9%
Detecting	-	0.0%	0.0%
Correcting	-	0.0%	0.0%
Disposing	8,740	3.9%	19.1%
Reporting	-	0.0%	0.0%
Total environmental	45,833	20.5%	100.0%
Non environmental	177,650	79.5%	
Cost	223,483	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
14	Building Maintanence								
14-01	Dispose Waste	0	0	0	8,740	0	8,740	9,988	87.5%
14-02	Process Waste	3,121	0	0	0	0	3,121	3,746	83.3%
14-03	Conduct Maintanence	26,506	0	0	0	0	26,506	137,336	19.3%
14-04	Get Material	0	0	0	0	0	0	9,988	0.0%
14-05	Prepare for Maintanence Work	4,994	0	0	0	0	4,994	27,467	18.2%
14-06	Attend Training Meetings	936	0	0	0	0	936	11,237	8.3%
14-07	Manage Building Maintanence	1,536	0	0	0	0	1,536	23,722	6.5%
Subtotal Building Maintanence		37,093	0	0	8,740	0	45,833	223,483	20.5%

Holston Activity and Task Summary

Session 14 Building Maintanence

Date 8/6/97 6 Participants Claude Gobble, Bob Stapeton, Paul Fields, Jim Thomas, Paul Sluss, Dale Harr Observers Ennis, Glenn, Keith, Mark

Time 8:00 FTE: 9 126 Years Experience Note

Activity **14-01**

Dispose Waste

Activity Note: Activity Driver Candidates, Production

Task	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Clean Shop	0.1	1,249	0.5	0	0	0	0		0	0	0	0	0
2 Dispose Grit	0.1	2,497	1	0	0	0	0	100	0	0	0	100	0
3 Dispose Paint Waste	0.1	2,497	1	0	0	0	0	100	0	0	0	100	0
4 Dispose Treated Water	0.1	1,249	0.5	0	0	0	0	100	0	0	0	100	0
5 Dispose Still Bottom	0.1	2,497	1	0	0	0	0	100	0	0	0	100	0
6 Saw Dust Disposal	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.4	9,988	4	0	0	0	0						
		8,740	87.5%					87.5%	0	0	0	8,740	0

Activity **14-02**

Process Waste

Activity Note: Activity Driver Candidates, Production

Task	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Store Grit	0.0	0	0	0	0	0	0		0	0	0	0	0
2 Distill Thinner	0.1	2,497	1	0	0	0	0	100	100	0	0	0	0
3 Store Paint Waste	0.0	0	0	0	0	0	0		0	0	0	0	0
4 Saw Dust Collector	0.1	1,249	0.5	0	0	0	0	50	50	0	0	0	0
5 Collect Samples	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.2	3,746	1.5	0	0	0	0						
		3,121	83.3%					83.3%	3,121	0	0	0	0

Activity **14-03**

Conduct Maintanence

Activity Note: Activity Driver Candidates, Production

Task	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Get Tools	0.2	4,994	2	0	0	0	0		0	0	0	0	0
2 Sand Blast	0.3	7,491	3	0	0	0	0	50	50	0	0	0	0
3 Get Material	0.2	4,994	2	0	0	0	0		0	0	0	0	0
4 Clean-up Tools	0.4	8,740	3.5	0	0	0	0	40	40	0	0	0	0
5 Repair Roofs	0.4	8,740	3.5	0	0	0	0	10	10	0	0	0	0
6 Prenventative Maintence on Shop Equipment	0.2	3,746	1.5	0	0	0	0	1	1	0	0	0	0

Task	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
7 Sign Painting	0.2	4,994	2	0	0	0	0	10	10	0	0	0	0
8 Replace Glass	0.3	7,491	3	0	0	0	0		0	0	0	0	0
9 Build Tent	0.1	1,249	0.5	0	0	0	0	100	100	0	0	0	0
10 Spray Booth	0.0	0	0	0	0	0	0		0	0	0	0	0
12 Repair Production Building	1.3	32,461	13	0	0	0	0	30	30	0	0	0	0
13 Concrete	0.5	12,485	5	0	0	0	0		0	0	0	0	0
14 Paint Buildings	1.1	27,467	11	0	0	0	0	25	25	0	0	0	0
15 Caulking Latex, Rubber	0.4	9,988	4	0	0	0	0		0	0	0	0	0
16 Lay Brick	0.1	2,497	1	0	0	0	0		0	0	0	0	0
Activity Total	5.5	137,336	55	0	0	0	0						
		26,506	19.3%					19.3%	26,506	0	0	0	0

Activity **14-04**

Get Material

Activity Note

Activity Driver Candidates Production

Task	*FTE*	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Order/Receive Materials	0.2	4,994	2	0	0	0	0		0	0	0	0	0
2 Order Paint	0.1	2,497	1	0	0	0	0		0	0	0	0	0
3 Receive Blasting Grit	0.0	0	0	0	0	0	0		0	0	0	0	0
4 Lacquer Thinner	0.0	0	0	0	0	0	0		0	0	0	0	0
5 Oil Paint	0.0	0	0	0	0	0	0		0	0	0	0	0
6 Denso Tape	0.1	2,497	1	0	0	0	0		0	0	0	0	0
Activity Total	0.4	9,988	4	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **14-05**

Prepare for Maintanence Work

Activity Note

Activity Driver Candidates Production

Task	*FTE*	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Inspect Buildings	0.4	9,988	4	0	0	0	0	25	25	0	0	0	0
2 Receive Work Orders	0.1	2,497	1	0	0	0	0		0	0	0	0	0
3 Go to Job Site	0.2	4,994	2	0	0	0	0		0	0	0	0	0
4 Make Sketches	0.1	1,249	0.5	0	0	0	0		0	0	0	0	0
6 Inspect Job	0.2	3,746	1.5	0	0	0	0		0	0	0	0	0
7 Read Blueprints	0.1	2,497	1	0	0	0	0		0	0	0	0	0
8 Check for Lead	0.1	2,497	1	0	0	0	0	100	100	0	0	0	0
Activity Total	1.1	27,467	11	0	0	0	0						
		4,994	18.2%					18.2%	4,994	0	0	0	0

Holston Activity and Task Summary

Session 14 Building Maintanence

Activity **14-06**

Attend Training Meetings

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Safety Meetings	0.3	6,243	2.5	0	0	0	0	15	15	0	0	0	0
2 Schedule Training	0.1	2,497	1	0	0	0	0		0	0	0	0	0
3 Training	0.1	2,497	1	0	0	0	0		0	0	0	0	0
Activity Total	0.5	11,237	4.5	0	0	0	0						
		936	8.3%					8.3%	936	0	0	0	0

Activity **14-07**

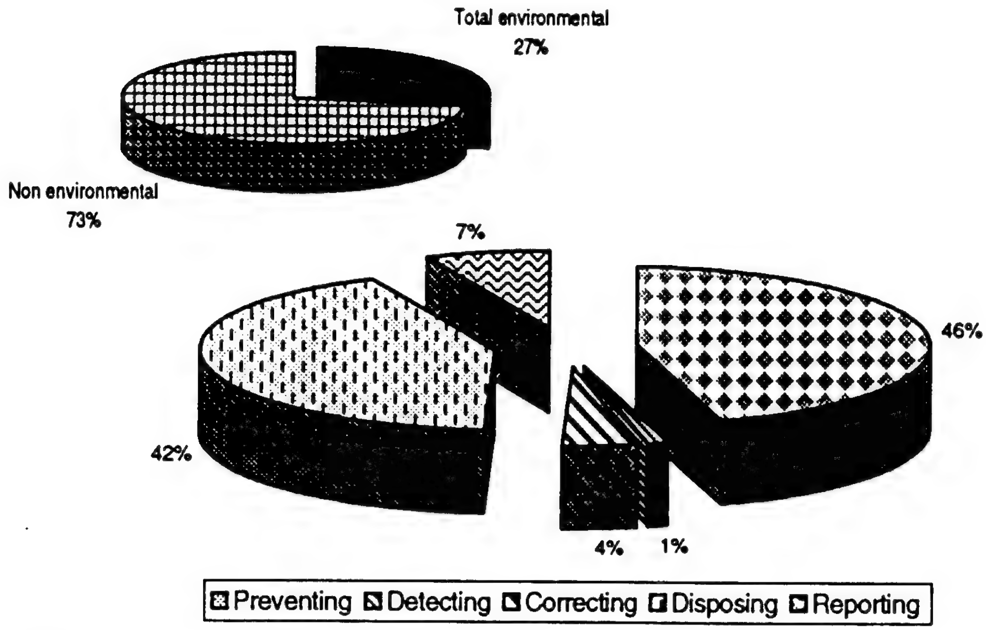
Manage Building Maintanence

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Put Time in Computer	0.1	2,497	1	0	0	0	0		0	0	0	0	0
2 Take Call	0.2	3,746	1.5	0	0	0	0		0	0	0	0	0
3 Assign Work Orders	0.2	3,746	1.5	0	0	0	0	1	1	0	0	0	0
4 Estimate Cost	0.3	7,491	3	0	0	0	0	10	10	0	0	0	0
5 Information for MOE	0.1	2,497	1	0	0	0	0	5	5	0	0	0	0
6 Follow Up	0.1	1,249	0.5	0	0	0	0		0	0	0	0	0
7 Meeting	0.1	2,497	1	0	0	0	0	25	25	0	0	0	0
Activity Total	1.0	23,722	9.5	0	0	0	0						
		1,536	6.5%					6.5%	1,536	0	0	0	0
Session Total	9.0	223,483	89.5	0	0	0	0						
		45,833	20.5%						37,093	0	0	8,740	0

Roads & Grounds Maintenance



Session Number	15		
Group	Roads & Grounds Maintenance		
Organization	Maintenance		

Category	Cost	% of Total	% of Environmental
Preventing	73,909	12.2%	45.4%
Detecting	1,477	0.2%	0.9%
Correcting	7,172	1.2%	4.4%
Disposing	69,240	11.4%	42.5%
Reporting	11,172	1.8%	6.9%
Total environmental	162,970	26.9%	100.0%
Non environmental	443,953	73.1%	
Cost	606,923	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
15	Roads & Grounds Maintenance								
15-01	Coordinate Resources	0	1,477	0	0	633	2,109	10,547	20.0%
15-02	Operate Landfill	26,027	0	0	55,635	8,008	89,670	159,741	56.1%
15-03	Clean Area	8,437	0	0	12,656	0	21,093	25,312	83.3%
15-04	Deliver Materials	11,812	0	0	0	0	11,812	65,390	18.1%
15-05	Contain Spills	4,219	0	0	0	0	4,219	4,219	100.0%
15-06	Operate Equipment	0	0	5,062	0	0	5,062	37,968	13.3%
15-07	Maintain Roads	0	0	0	0	0	0	61,171	0.0%
15-08	Maintain Grounds	0	0	0	0	0	0	71,718	0.0%
15-09	Prepare for Work	0	0	0	0	0	0	4,219	0.0%
15-10	Control Pests and Vegitation	21,937	0	0	0	2,109	24,047	73,827	32.6%
15-11	Attend Training	0	0	0	0	0	0	10,547	0.0%
15-12	Coordinate Daily Work	1,477	0	2,109	949	422	4,957	82,265	6.0%
Subtotal Roads & Grounds Maintenance		73,909	1,477	7,172	69,240	11,172	162,970	606,923	26.9%

Holston Activity and Task Summary

Session 15 Roads & Grounds Maintenance

Date	8/6/96	5 Participants	David Cowden, Tom Hatley, Sam Stewart, John Sprinkle, Glenn Templeton	Observers	Ennis, Glenn, Keith, Mark
Time	1:00	FTE:	12 81 Years Experience	Note	

Activity **15-01**

Coordinate Resources

Activity Note

Activity Driver Candidates Facility

	FTE	Cost	People Time	-	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Wildlife Control	0.1	4,219	1	0	0	0	0		0	0	0	0	0
2 Manage Natural Resources	0.1	4,219	1	0	0	0	0		0	0	0	0	0
3 Coordinate Land Leases	0.0	0	0	0	0	0	0		0	0	0	0	0
4 Monitor Old Landfill/Flyash	0.0	2,109	0.5	0	0	0	0	100	0	70	0	0	30
Activity Total	0.2	10,547	2.5	0	0	0	0						
		2,109	20.0%					20.0%	0	1,477	0	0	633

Activity **15-02**

Operate Landfill

Activity Note

Activity Driver Candidates Facility

	FTE	Cost	People Time	-	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Daily Inspection of Leatchate System	0.0	4,004	0.5	0	0	0	0	100	100	0	0	0	0
2 Daily Landfill Records	0.1	8,008	1	0	0	0	0	100	0	0	0	0	100
3 Cover Trash	0.3	24,025	3	0	0	0	0	50	50	0	0	0	0
4 Haul Leatchate Water	0.0	4,004	0.5	0	0	0	0	100	0	0	0	100	0
5 Open Gate to Landfill	0.0	0	0	0	0	0	0		0	0	0	0	0
6 Go to Landfill Office	0.0	4,004	0.5	0	0	0	0		0	0	0	0	0
7 Check Leatchate Tanks	0.0	0	0	0	0	0	0		0	0	0	0	0
8 Compact Trash	0.3	24,025	3	0	0	0	0	50	0	0	0	50	0
9 Haul Gravel	0.0	0	0	0	0	0	0		0	0	0	0	0
10 Haul Dirt for the Day	0.2	20,020	2.5	0	0	0	0	50	50	0	0	0	0
11 Haul Trash to Landfill	0.8	64,065	8	0	0	0	0	50	0	0	0	50	0
12 Operate Incinerator	0.0	7,586	0	0	0	0	0	100	0	0	0	100	0
Activity Total	1.8	159,741	19	0	0	0	0						
		89,670	53.9%					56.1%	26,027	0	0	55,635	8,008

Activity **15-03**

Clean Area

Activity Note

Activity Driver Candidates Production

	FTE	Cost	People Time	-	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Clean Mixing Bldg	0.1	4,219	1	0	0	0	0	100	100	0	0	0	0
2 Clean Ditch	0.0	0	0	0	0	0	0		0	0	0	0	0

3 Clean and Remove Waste from Drying Bed Sewer Plant	0.1	4,219	1	0	0	0	0	100	0	0	0	100	0
4 Clean-up Burning Grounds	0.1	4,219	1	0	0	0	0	100	0	0	0	100	0
5 Clean-up Spills	0.1	4,219	1	0	0	0	0	100	100	0	0	0	0
6 Pick-up Trash	0.1	4,219	1	0	0	0	0		0	0	0	0	0
7 Clean Water Intake	0.0	0	0	0	0	0	0		0	0	0	0	0
8 Clean Bird Mess from Bldgs	0.1	4,219	1	0	0	0	0	100	0	0	0	100	0
9 Clean Basins Waste Water Plant	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.6	25,312	6	0	0	0	0						
		21,093	83.3%					83.3%	8,437	0	0	12,656	0

Activity **15-04**

Deliver Materials

				Activity Note									
				Activity Driver Candidates			Production						
	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Receive Material & Unload Material	0.2	8,437	2	0	0	0	0	40	40	0	0	0	0
2 Local Buying Office Run	0.3	14,765	3.5	0	0	0	0		0	0	0	0	0
3 Deliver Supplies to all Depts.	0.5	21,093	5	0	0	0	0	40	40	0	0	0	0
4 Tool Room Issue Tools & Supplies	0.2	8,437	2	0	0	0	0		0	0	0	0	0
5 Haul Cylinders	0.1	4,219	1	0	0	0	0		0	0	0	0	0
6 Move Paper to Reproduction	0.1	4,219	1	0	0	0	0		0	0	0	0	0
7 Move Furniture	0.1	4,219	1	0	0	0	0		0	0	0	0	0
Activity Total	1.5	65,390	15.5	0	0	0	0						
		11,812	18.1%					18.1%	11,812	0	0	0	0

Activity **15-05**

Contain Spills

				Activity Note									
				Activity Driver Candidates			Production						
	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Make Sandbags to Replenish Old Sandbag Sites	0.1	4,219	1	0	0	0	0	100	100	0	0	0	0
2 Build Dikes	0.0	0	0	0	0	0	0		0	0	0	0	0
3 Inspect Dikes	0.0	0	0	0	0	0	0		0	0	0	0	0
4 Install Silt Fences	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.1	4,219	1	0	0	0	0						
		4,219	100.0%					100.0%	4,219	0	0	0	0

Holston Activity and Task Summary

Session 15 Roads & Grounds Maintenance

Activity 15-06

Operate Equipment

				Activity Note									
				Activity Driver Candidates			Production						
	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Operate Forklifts as Required	0.1	4,219	1	0	0	0	0		0	0	0	0	0
2 Dig Out Water Lines for Repairs	0.2	8,437	2	0	0	0	0	60	0	0	60	0	0
3 Operate Boom Trunk as Required	0.2	8,437	2	0	0	0	0		0	0	0	0	0
4 Haul Metal from Burning Ground to Salvage After Pile Run	0.2	8,437	2	0	0	0	0		0	0	0	0	0
5 Drive Vehicle to GSA for Exchange	0.1	4,219	1	0	0	0	0		0	0	0	0	0
6 Drive GSA Vehicle to Off-Post Repair and Tire Shop	0.1	4,219	1	0	0	0	0		0	0	0	0	0
Activity Total	0.9	37,968	9	0	0	0	0						
		5,062	13.3%					13.3%	0	0	5,062	0	0

Activity 15-07

Maintain Roads

				Activity Note									
				Activity Driver Candidates			Production						
	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Haul and Spread Gravel Where Needed	0.2	8,437	2	0	0	0	0		0	0	0	0	0
2 Grade Dirt and Gravel Roads	0.3	12,656	3	0	0	0	0		0	0	0	0	0
3 Remove Snow and Ice from Parking Lots	0.3	12,656	3	0	0	0	0		0	0	0	0	0
4 Remove Snow and Ice from all Roads	0.3	14,765	3.5	0	0	0	0		0	0	0	0	0
5 Remove Snow and Ie from Bldg Walks	0.3	12,656	3	0	0	0	0		0	0	0	0	0
Activity Total	1.4	61,171	14.5	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity 15-08

Maintain Grounds

				Activity Note									
				Activity Driver Candidates			Facility						
	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Maintanence to Igloos, Dirt, and Glass	0.3	12,656	3	0	0	0	0		0	0	0	0	0
2 Mow Power Lines	0.3	12,656	3	0	0	0	0		0	0	0	0	0
3 Weed Eat Where Mowes Can't Go	0.3	12,656	3	0	0	0	0		0	0	0	0	0
4 Mow Waste Water Line	0.2	8,437	2	0	0	0	0		0	0	0	0	0
5 Mow Fencw Right Of Ways	0.3	12,656	3	0	0	0	0		0	0	0	0	0
6 Break Concrete w/ Backhoe Breaker	0.1	4,219	1	0	0	0	0		0	0	0	0	0
7 Core Drill Concrete Hole	0.1	4,219	1	0	0	0	0		0	0	0	0	0
8 Repair Fences	0.1	4,219	1	0	0	0	0		0	0	0	0	0
9 Mow the Landfill	0.0	0	0	0	0	0	0		0	0	0	0	0

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
Activity Total	1.6	71,718	17	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **15-09**

Prepare for Work

	FTE	Cost	People Time	Activity Note Activity Driver Candidates -	-	-	Facility -	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Get Vehicle	0.1	4,219	1	0	0	0	0		0	0	0	0	0
2 Get Tools	0.0	0	0	0	0	0	0		0	0	0	0	0
3 Dump Truck Check Out	0.0	0	0	0	0	0	0		0	0	0	0	0
4 Drive to Workplace	0.0	0	0	0	0	0	0		0	0	0	0	0
5 Sign-Out Gate Keys from Security for Work Areas	0.0	0	0	0	0	0	0		0	0	0	0	0
6 Check Tractor, Laoder, Backhoe, Etc. to be Used	0.0	0	0	0	0	0	0		0	0	0	0	0
7 Check the Equipment Out, Oil, Fuel, & Leaks	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.1	4,219	1	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **15-10**

Control Pests and Vegitation

	FTE	Cost	People Time	Activity Note Activity Driver Candidates -	-	-	Facility -	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Check for Leaks in Inventory Containers	0.1	4,219	1	0	0	0	0	100	100	0	0	0	0
2 Rodent Control	0.1	4,219	1	0	0	0	0		0	0	0	0	0
3 Monthly Pest Control Records	0.0	2,109	0.5	0	0	0	0	100	0	0	0	0	100
4 Get Keys to Spray Bldgs	0.0	0	0	0	0	0	0		0	0	0	0	0
5 Mix Chemicals	0.2	8,437	2	0	0	0	0		0	0	0	0	0
6 Get Clothes, Gloves, Respirators, Glasses	0.2	8,437	2	0	0	0	0		0	0	0	0	0
7 Discuss Areas to be Sprayed and Treated	0.1	4,219	1	0	0	0	0	20	20	0	0	0	0
8 Apply Spray	1.0	42,187	10	0	0	0	0	40	40	0	0	0	0
Activity Total	1.7	73,827	17.5	0	0	0	0						
		24,047	32.6%					32.6%	21,937	0	0	0	2,109

Activity **15-11**

Attend Training

	FTE	Cost	People Time	Activity Note Activity Driver Candidates -	-	-	Facility -	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 OJT Continually	0.0	0	0	0	0	0	0		0	0	0	0	0

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
2 Safety Training and Meeting Every Tuesday	0.1	6,328	1.5	0	0	0	0		0	0	0	0	0
3 Training	0.1	4,219	1	0	0	0	0		0	0	0	0	0
Activity Total	0.2	10,547	2.5	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **15-12**

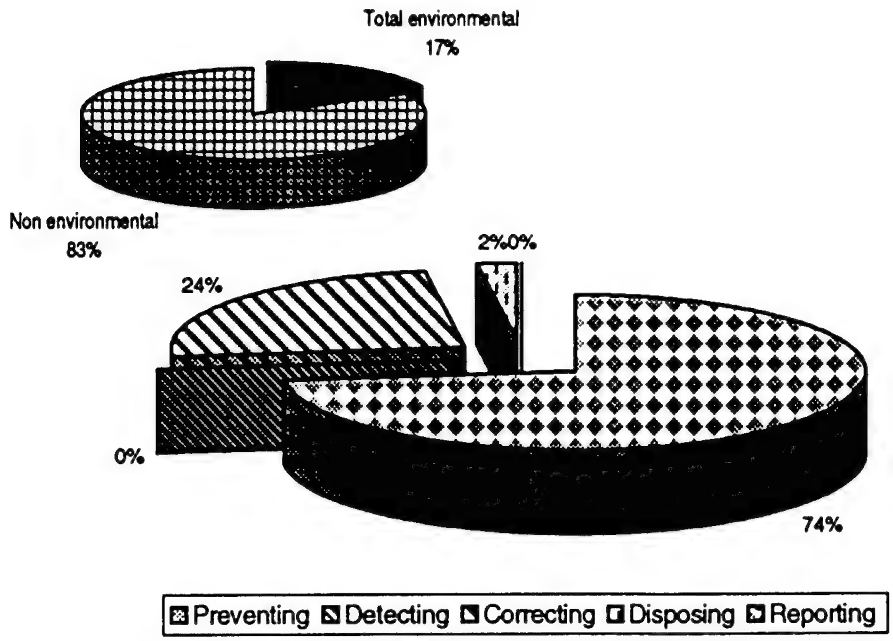
Coordinate Daily Work

Activity Note

Activity Driver Candidates Production

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Notify Safety Inspector if Permit Needed	0.1	4,219	1	0	0	0	0	20	20	0	0	0	0
2 Check Phone and Computer for Messages	0.2	10,547	2.5	0	0	0	0	1	1	0	0	0	0
3 Coordinate Daily Work of Dept.	0.3	12,656	3	0	0	0	0		0	0	0	0	0
4 Answer Questions	0.2	10,547	2.5	0	0	0	0	10	5	0	0	5	0
5 Fill Out Time Sheets	0.0	0	0	0	0	0	0		0	0	0	0	0
6 Attend Meetings	0.2	10,547	2.5	0	0	0	0	20	0	0	20	0	0
7 Write Work Orders	0.1	6,328	1.5	0	0	0	0		0	0	0	0	0
10 Paper Work for the Day	0.2	10,547	2.5	0	0	0	0		0	0	0	0	0
11 Daily Spray Records	0.1	4,219	1	0	0	0	0	10	0	0	0	0	10
12 Receive Job Assignments	0.1	4,219	1	0	0	0	0	10	0	0	0	10	0
13 Process Supplies for Dept.	0.2	8,437	2	0	0	0	0		0	0	0	0	0
Activity Total	1.9	82,265	19.5	0	0	0	0						
		4,957	6.0%					6.0%	1,477	0	2,109	949	422
Session Total	12.0	606,923	125	0	0	0	0						
		162,970	22.1%						73,909	1,477	7,172	69,240	11,172

Electrical & Instrumental



Session Number 16
Group Electrical & Instrumental
Organization Maintenance

Category	Cost	% of Total	% of Environmental
Preventing	111,631	12.8%	73.5%
Detecting	-	0.0%	0.0%
Correcting	36,862	4.2%	24.3%
Disposing	3,478	0.4%	2.3%
Reporting	-	0.0%	0.0%
Total environmental	151,971	17.5%	100.0%
Non environmental	717,427	82.5%	
Cost	869,398	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
16	Electrical & Instrumental								
16-01	Dispose of Materials and Parts	0	0	0	3,478	0	3,478	10,433	33.3%
16-02	Procure Parts/Equipment	261	0	1,391	0	0	1,652	31,298	5.3%
16-03	Maintain UPS	869	0	0	0	0	869	12,172	7.1%
16-04	Calibrate Equipmet	37,210	0	0	0	0	37,210	149,536	24.9%
16-05	Maintain Facilities/Equipment	56,946	0	35,471	0	0	92,417	438,176	21.1%
16-06	Prepare for Work	6,955	0	0	0	0	6,955	114,761	6.1%
16-07	Train Personnel	9,389	0	0	0	0	9,389	60,858	15.4%
16-08	Manage Operations	0	0	0	0	0	0	52,164	0.0%
Subtotal Electrical & Instrumental		111,631	0	36,862	3,478	0	151,971	869,398	17.5%

Holston Activity and Task Summary

Session 16 Electrical & Instrumental

Date 8/7/97 | 5 Participants | Jim Smith, Johny Mullins, Ken Zollman, Eddie Short, Danny Price | Observers | Ennis, Glenn, Keith, Mark

Time 8:00 | FTE: | 31 111 Years Experience | Note

Activity **16-01**

Dispose of Materials and Parts

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Dispose of Old Power Line Refuse	0.0	0	0	0	0	0	0		0	0	0	0	0
2 Store Flourescent Lights for Disposal	0.0	0	0	0	0	0	0		0	0	0	0	0
3 Disposal Procudures for Capital Equipment	0.1	3,478	1	0	0	0	0		0	0	0	0	0
4 Dispose of Part	0.1	3,478	1	0	0	0	0		0	0	0	0	0
5 Maintain PCB Storage Facility	0.0	0	0	0	0	0	0		0	0	0	0	0
6 Battery Disposal	0.1	3,478	1	0	0	0	0	100	0	0	0	100	0
Activity Total	0.4	10,433	3	0	0	0	0						
		3,478	33.3%					33.3%	0	0	0	3,478	0

Activity **16-02**

Procure Parts/Equipment

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Send Out for Repairs	0.2	5,216	1.5	0	0	0	0	5	5	0	0	0	0
2 Shop Parts	0.2	6,955	2	0	0	0	0		0	0	0	0	0
3 Check On Replacement or Repair	0.2	5,216	1.5	0	0	0	0		0	0	0	0	0
4 Parts for Repair on Hand or Order	0.5	13,910	4	0	0	0	0	10	0	0	10	0	0
Activity Total	1.1	31,298	9	0	0	0	0						
		1,652	5.3%					5.3%	261	0	1,391	0	0

Activity **16-03**

Maintain UPS

Activity Note

Activity Driver Candidates Facility

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Check Uninterupted Power Source	0.2	5,216	1.5	0	0	0	0	10	10	0	0	0	0
2 Check Batteries	0.2	6,955	2	0	0	0	0	5	5	0	0	0	0
3 Replace UPS	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.4	12,172	3.5	0	0	0	0						
		869	7.1%					7.1%	869	0	0	0	0

Holston Activity and Task Summary

Session 16 Electrical & Instrumental

Activity **16-04**

Calibrate Equipmet

	FTE	Cost	People Time	-	-	-	- Production	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Routine Testing	1.4	38,254	11	0	0	0	0	40	40	0	0	0	0
2 Calibration	0.6	17,388	5	0	0	0	0	40	40	0	0	0	0
3 Test Equipment Certification	0.5	13,910	4	0	0	0	0	10	10	0	0	0	0
4 Scales Certification	0.2	6,955	2	0	0	0	0		0	0	0	0	0
5 Repair Shop Equipment	0.4	10,433	3	0	0	0	0		0	0	0	0	0
6 Measure Temp	0.5	13,910	4	0	0	0	0	10	10	0	0	0	0
7 Testing Pressure Vessel	0.9	24,343	7	0	0	0	0	50	50	0	0	0	0
8 Testing Lifting Equipment	0.9	24,343	7	0	0	0	0		0	0	0	0	0
Activity Total	5.3	149,536	43	0	0	0	0						
		37,210	24.9%					24.9%	37,210	0	0	0	0

(Activity Note: Activity Driver Candidates)

Activity **16-05**

Maintain Facilities/Equipment

	FTE	Cost	People Time	-	-	-	- Production	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Elevator Maintanence	0.3	8,694	2.5	0	0	0	0		0	0	0	0	0
2 Mounting & Maintaining Warning Signs	0.2	6,955	2	0	0	0	0		0	0	0	0	0
3 Maintain Transporters	0.7	20,866	6	0	0	0	0	5	5	0	0	0	0
4 Maintain Substations	0.6	17,388	5	0	0	0	0		0	0	0	0	0
5 24 Hour Troubleshooting	1.7	48,686	14	0	0	0	0	30	30	0	0	0	0
6 Check PH Meter	0.6	15,649	4.5	0	0	0	0	100	100	0	0	0	0
7 Valve Maintanence	0.4	12,172	3.5	0	0	0	0	5	5	0	0	0	0
8 Transformer Maintanence	0.6	17,388	5	0	0	0	0	10	10	0	0	0	0
9 Maintain A/C	1.0	27,821	8	0	0	0	0	75	0	0	75	0	0
10 Maintain Power Line Equip	0.4	10,433	3	0	0	0	0		0	0	0	0	0
11 Maintain Power Lines	1.1	31,298	9	0	0	0	0	30	30	0	0	0	0
12 Maintain Electrical Systems	1.4	38,254	11	0	0	0	0		0	0	0	0	0
13 Radio Repair	0.2	6,955	2	0	0	0	0		0	0	0	0	0
14 Air Monitoring	0.2	6,955	2	0	0	0	0	100	100	0	0	0	0
15 Shop Cleanup	0.2	5,216	1.5	0	0	0	0		0	0	0	0	0
16 Electrical Construction	1.6	45,209	13	0	0	0	0		0	0	0	0	0
17 Instrument Construction	0.5	13,910	4	0	0	0	0	5	5	0	0	0	0
18 Control Systems	1.1	31,298	9	0	0	0	0	20	20	0	0	0	0
19 Find Problem	2.6	73,029	21	0	0	0	0	20	0	0	20	0	0

(Activity Note: Activity Driver Candidates)

Holston Activity and Task Summary

Session 16 Electrical & Instrumental

	FTE	Cost	People Time	-	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
Activity Total	15.6	438,176	126	0	0	0	0						
		92,417	21.1%					21.1%	56,946	0	35,471	0	0

Activity **16-06**

Prepare for Work

Activity Note

Activity Driver Candidates Production

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Change Clothes	0.1	1,739	0.5	0	0	0	0		0	0	0	0	0
2 Call Operator	0.1	1,739	0.5	0	0	0	0		0	0	0	0	0
3 Planning	1.1	31,298	9	0	0	0	0	20	20	0	0	0	0
4 Equipment Needed to Perform Check-Out	0.4	10,433	3	0	0	0	0		0	0	0	0	0
5 Prioritize Work	0.5	13,910	4	0	0	0	0	5	5	0	0	0	0
6 Safety Requirements	0.6	15,649	4.5	0	0	0	0		0	0	0	0	0
7 Check Tools	0.1	3,478	1	0	0	0	0		0	0	0	0	0
9 Transport Equipment	0.0	0	0	0	0	0	0		0	0	0	0	0
10 Check Material	0.7	20,866	6	0	0	0	0		0	0	0	0	0
11 Check Vehicles	0.0	0	0	0	0	0	0		0	0	0	0	0
12 Go to Jobsite	0.0	0	0	0	0	0	0		0	0	0	0	0
13 Get Work Order	0.1	1,739	0.5	0	0	0	0		0	0	0	0	0
14 Pull Blue Prints	0.2	6,955	2	0	0	0	0		0	0	0	0	0
15 Red Line Prints	0.2	6,955	2	0	0	0	0		0	0	0	0	0
Activity Total	4.1	114,761	33	0	0	0	0						
		6,955	6.1%					6.1%	6,955	0	0	0	0

Activity **16-07**

Train Personnel

Activity Note

Activity Driver Candidates Facility

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Computer Training	0.4	10,433	3	0	0	0	0		0	0	0	0	0
2 SPCC Training	0.1	3,478	1	0	0	0	0	100	100	0	0	0	0
3 Mandatoy Training	1.2	34,776	10	0	0	0	0	10	10	0	0	0	0
4 Safety Meeting	0.4	12,172	3.5	0	0	0	0	20	20	0	0	0	0
5 Ladder Training	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	2.2	60,858	17.5	0	0	0	0						
		9,389	15.4%					15.4%	9,389	0	0	0	0

Holston Activity and Task Summary

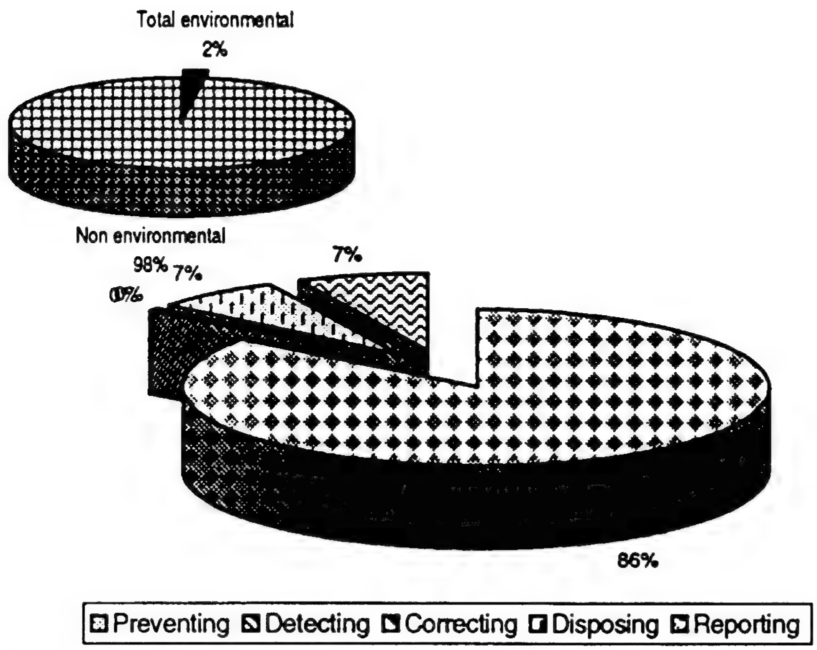
Session 16 Electrical & Instrumental

Activity **16-08**

Manage Operations

	FTE	Cost	People Time	Activity Note -	Activity Driver Candidates -	-	Production -	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Time Keeping	0.9	26,082	7.5	0	0	0	0		0	0	0	0	0
2 Open Close Work Orders	0.9	26,082	7.5	0	0	0	0		0	0	0	0	0
Activity Total	1.9	52,164	15	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0
Session Total	31.0	869,398	250	0	0	0	0						
		151,971	17.5%						111,631	0	36,862	3,478	0

Corporate Business Planning



Session Number	17		
Group	Corporate Business Planning		
Organization	Support		

Category	Cost	% of Total	% of Environmental
Preventing	3,455	2.0%	85.4%
Detecting	-	0.0%	0.0%
Correcting	15	0.0%	0.4%
Disposing	281	0.2%	6.9%
Reporting	295	0.2%	7.3%
Total environmental	4,046	2.3%	100.0%
Non environmental	173,143	97.7%	
Cost	177,189	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
17	Corporate Business Planning								
17-01	Coordinate Special Projects	886	0	0	0	0	886	20,672	4.3%
17-02	Coordinate Facilities	30	0	0	0	0	30	14,766	0.2%
17-03	Plan Production	783	0	15	59	0	856	53,157	1.6%
17-04	Receive Training	177	0	0	0	0	177	8,859	2.0%
17-05	Market to Third Parties	989	0	0	221	295	1,506	38,391	3.9%
17-06	Develop Business	591	0	0	0	0	591	17,719	3.3%
17-07	Present Meetings	0	0	0	0	0	0	23,625	0.0%
Subtotal Corporate Business Planning		3,455	0	15	281	295	4,046	177,189	2.3%

Holston Activity and Task Summary

Session 17 Corporate Business Planning

Date 8/8/97 | 2 Participants | Imogene Bishop, George Tittsworth | Observers | Ennis, Glenn, Keith, Mark

Time 8:00 | FTE: | 3 58 Years Experience | Note

Activity **17-01**

Coordinate Special Projects

Activity Note: Activity Driver Candidates Production

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Special Projects	0.2	11,813	2	0	0	0	0	5	5	0	0	0	0
2 XMAT (Contract)	0.1	2,953	0.5	0	0	0	0	10	10	0	0	0	0
3 Problem Solving	0.1	5,906	1	0	0	0	0		0	0	0	0	0
Activity Total	0.3	20,672	3.5	0	0	0	0						
		886	4.3%					4.3%	886	0	0	0	0

Activity **17-02**

Coordinate Facilities

Activity Note: Activity Driver Candidates Facility

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Storage Management-Coordinate Warehouse Storage	0.1	2,953	0.5	0	0	0	0		0	0	0	0	0
2 Industrial Stock Coordinator Production Mgmt	0.1	2,953	0.5	0	0	0	0	1	1	0	0	0	0
3 Industrial Preparedness Plan Outyear Production/Replenishment	0.1	2,953	0.5	0	0	0	0		0	0	0	0	0
4 FYDP Coordinator 5 yr. Defense Program	0.1	2,953	0.5	0	0	0	0		0	0	0	0	0
5 Coordinate Technical Support	0.1	2,953	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.3	14,766	2.5	0	0	0	0						
		30	0.2%					0.2%	30	0	0	0	0

Activity **17-03**

Plan Production

Activity Note: Activity Driver Candidates Production

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Contract Pricing Proposal (CPP)	0.1	8,859	1.5	0	0	0	0	5	5	0	0	0	0
2 Production Schedule	0.1	5,906	1	0	0	0	0		0	0	0	0	0
3 Cost Estimate	0.1	2,953	0.5	0	0	0	0	3	1.5	0	0	1.5	0
4 Coordinate Bill of Material Master	0.1	2,953	0.5	0	0	0	0		0	0	0	0	0
5 Production Acceptance Reports	0.1	2,953	0.5	0	0	0	0		0	0	0	0	0
6 Contract Line Item No. Mgmt	0.1	5,906	1	0	0	0	0		0	0	0	0	0
7 Monitor Production Cost	0.1	5,906	1	0	0	0	0	5	5	0	0	0	0
8 Funding on Production Items	0.1	2,953	0.5	0	0	0	0		0	0	0	0	0

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
9 Request Undated Funding From IOC (Overruns)	0.1	2,953	0.5	0	0	0	0	1	0	0	0.5	0.5	0
10 Production Acceptance Schedule Coordinate	0.1	5,906	1	0	0	0	0		0	0	0	0	0
11 Order Releases	0.1	5,906	1	0	0	0	0		0	0	0	0	0
12 Expl. Interfix Nos. Assign	0.0	0	0	0	0	0	0		0	0	0	0	0
13 Production Meeting w/ IOC @ IOC 2 Times a yr. Fine Tune Budget (CPP)	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.9	53,157	9	0	0	0	0						
		856	1.6%					1.6%	783	0	15	59	0

Activity **17-04**

Receive Training

Activity Note

Activity Driver Candidates Facility

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Internal Training	0.1	2,953	0.5	0	0	0	0	1	1	0	0	0	0
2 External Training	0.1	2,953	0.5	0	0	0	0	5	5	0	0	0	0
3 Safety Meetings	0.1	2,953	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.2	8,859	1.5	0	0	0	0						
		177	2.0%					2.0%	177	0	0	0	0

Activity **17-05**

Market to Third Parties

Activity Note

Activity Driver Candidates Production

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Price Product	0.1	2,953	0.5	0	0	0	0	5	2.5	0	0	2.5	0
3 Update Pricing Sheet	0.1	2,953	0.5	0	0	0	0		0	0	0	0	0
4 Process RFQ	0.1	5,906	1	0	0	0	0	5	2.5	0	0	2.5	0
5 Process Purchase Orders	0.1	2,953	0.5	0	0	0	0	1	1	0	0	0	0
6 Request Idemification from IOC	0.1	2,953	0.5	0	0	0	0	25	25	0	0	0	0
7 Mandatory Checklist (MC)	0.1	2,953	0.5	0	0	0	0	5	0	0	0	0	5
8 Notice of Intent (NOI)	0.1	2,953	0.5	0	0	0	0		0	0	0	0	0
10 Acknowledgement of Purchase Orders	0.1	2,953	0.5	0	0	0	0	5	0	0	0	0	5
11 Coordinate Production/Shipping	0.1	5,906	1	0	0	0	0		0	0	0	0	0
12 Invoice	0.1	2,953	0.5	0	0	0	0		0	0	0	0	0
13 Process Receipts	0.1	2,953	0.5	0	0	0	0		0	0	0	0	0
14 Record of Environmental Consideration (REC)	0.0	0	0	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 17 Corporate Business Planning

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
Activity Total	0.7	38,391	6.5	0	0	0	0						
		1,506	3.9%					3.9%	989	0	0	221	295

Activity **17-06**

Develop Business

Activity Note

Activity Driver Candidates Production

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Customer Contact	0.2	11,813	2	0	0	0	0		0	0	0	0	0
2 Development Coordination New Products/Blends	0.1	5,906	1	0	0	0	0	10	10	0	0	0	0
3 Coordinate New Program	0.0	0	0	0	0	0	0		0	0	0	0	0
4 Consult w/ Legal	0.0	0	0	0	0	0	0		0	0	0	0	0
Activity Total	0.3	17,719	3	0	0	0	0						
		591	3.3%					3.3%	591	0	0	0	0

Activity **17-07**

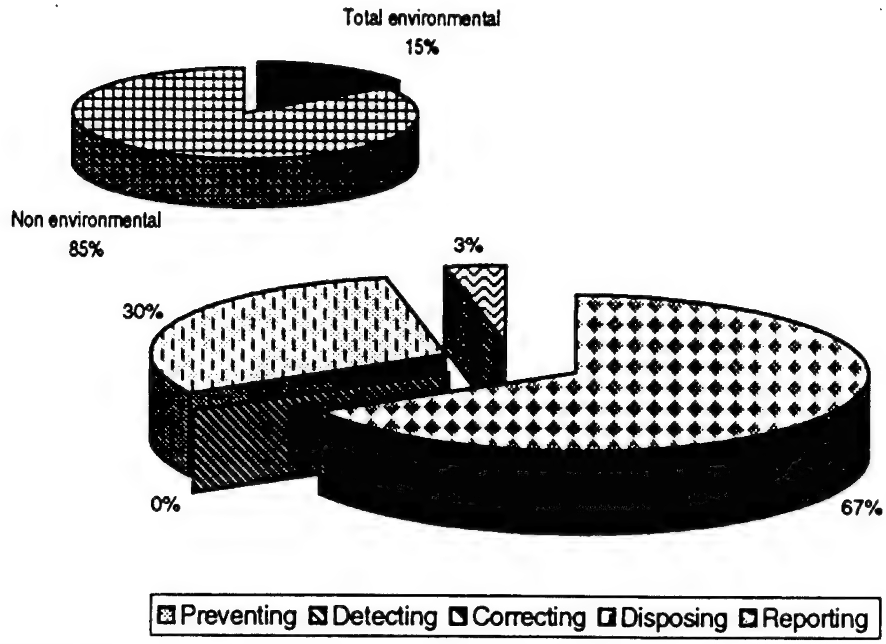
Present Meetings

Activity Note

Activity Driver Candidates Facility

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Mgmt Meetings/Briefings	0.3	17,719	3	0	0	0	0		0	0	0	0	0
2 Production Meetings	0.1	5,906	1	0	0	0	0		0	0	0	0	0
Activity Total	0.4	23,625	4	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0
Session Total	3.0	177,189	30	0	0	0	0						
		4,046	2.3%						3,455	0	15	281	295

Area Maintanence & Mechanical Services



Session Number	18
Group	Area Maintanence & Mechanical Services
Organization	Maintenance

Category	Cost	% of Total	% of Environmental
Preventing	198,944	9.9%	66.6%
Detecting	-	0.0%	0.0%
Correcting	-	0.0%	0.0%
Disposing	89,526	4.5%	30.0%
Reporting	10,253	0.5%	3.4%
Total environmental	298,723	14.9%	100.0%
Non environmental	1,705,902	85.1%	
Cost	2,004,625	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
18	Area Maintanence & Mechanical Services								
18-01	Maintain Equipment	62,848	0	0	0	0	62,848	261,928	24.0%
18-02	Perform Mechanical Functions	70,550	0	0	22,315	0	92,865	882,836	10.5%
18-03	Procure Material	0	0	0	0	0	0	238,084	0.0%
18-04	Handle Waste Material	24,419	0	0	67,212	0	91,630	185,817	49.3%
18-05	Prepare for Jobs	2,298	0	0	0	0	2,298	80,414	2.9%
18-06	Manage Paperwork	1,867	0	0	0	0	1,867	192,419	1.0%
18-07	Train Personnel	36,962	0	0	0	10,253	47,215	163,127	28.9%
Subtotal Area Maintanence & Mechanical Ser		198,944	0	0	89,526	10,253	298,723	2,004,625	14.9%

Holston Activity and Task Summary

Session 18 Area Maintanence & Mechanical Services

Date 8/11/97 5 Participants Bill Asmus, Homer Chandler, Don Mutter, Larry Reece, David Taylor Observers Ennis, Glenn, Keith, Mark, Alan, Ross

Time 8:00 FTE: 63 121 Years Experience Note

Activity **18-01**

Maintain Equipment

Activity Note: Activity Driver Candidates Facility

	FTE	Cost	People Time	Maintane nce (In	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
4 Inspect Equipment to be Used	0.4	19,817	2	1	0	0	0	2	2	0	0	0	0
7 Preventative Maintanence	2.0	82,427	10	3	0	0	0	50	50	0	0	0	0
8 Inspect and Check PM for Equipment	2.0	65,768	10	1	0	0	0	5	5	0	0	0	0
9 Inspect Cranes and Manlift Monthly	0.8	31,305	4	1	0	0	0	10	10	0	0	0	0
10 Maint on Back Hoes, Crane, Dozers, Compctrs, Air Com, Generator, Lrg. Trucks	0.4	19,817	2	1	0	0	0	10	10	0	0	0	0
11 Log Equipment Repair	1.2	42,793	6	1	0	0	0	30	30	0	0	0	0
Activity Total	6.7	261,928	34	8	0	0	0						
		62,848	23.4%	25.9%				24.0%	62,848	0	0	0	0

Activity **18-02**

Perform Mechanical Functions

Activity Note: Activity Driver Candidates Produciton

	FTE	Cost	People Time	Maintane nce (In	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Repair Steam Leaks	2.8	80,414	14	0	0	0	0		0	0	0	0	0
2 Repair Pumps	5.3	155,084	27	0	0	0	0	25	25	0	0	0	0
3 Repair/Install Columns	0.2	5,744	1	0	0	0	0		0	0	0	0	0
4 Install Piping/Pipe Fittings	3.1	91,902	16	0	0	0	0	10	10	0	0	0	0
6 Certified Welder	3.0	86,158	15	0	0	0	0		0	0	0	0	0
9 Wrigging	1.0	28,719	5	0	0	0	0		0	0	0	0	0
11 Iron Work	1.2	34,463	6	0	0	0	0	1	0	0	0	1	0
12 Boiler Maker	2.2	63,182	11	0	0	0	0	5	2.5	0	0	2.5	0
13 Repair Under Ground Pipe Breaks	0.0		0	0	0	0	0		0	0	0	0	0
14 Repair/Rebuild Gear Boxes	3.3	97,646	17	0	0	0	0	20	0	0	0	20	0
15 Operate Equipment	0.6	17,232	3	0	0	0	0		0	0	0	0	0
16 Install Tanks	0.4	11,488	2	0	0	0	0		0	0	0	0	0
17 Install Structural Steel Walkways, Steps, etc.s	0.2	5,744	1	0	0	0	0		0	0	0	0	0
18 Drill for Anchor	0.4	11,488	2	0	0	0	0		0	0	0	0	0
19 Repair Automotive Engineering Type EQ	1.0	70,367	5	5	0	0	0	25	25	0	0	0	0
20 Transport Equipment	0.6	25,561	3	1	0	0	0	10	10	0	0	0	0
21 Set Equipment	0.6	17,232	3	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 18 Area Maintanence & Mechanical Services

	FTE	Cost	People Time	Maintane nce (In	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
22 Fabrication	1.6	45,951	8	0	0	0	0		0	0	0	0	0
24 Air Compressors	1.2	34,463	6	0	0	0	0	5	2.5	0	0	2.5	0
Activity Total	28.5	882,836	145	6	0	0	0						
		92,865	9.8%	22.5%				10.5%	70,550	0	0	22,315	0

Activity **18-03**

Procure Material

Activity Note

Activity Driver Candidates Production

	FTE	Cost	People Time	Maintane nce (In	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Material for Job	0.2	5,744	1	0	0	0	0		0	0	0	0	0
2 Purchase Order Materials Out of Town	0.6	25,561	3	1	0	0	0		0	0	0	0	0
3 LBO Materials	1.4	40,207	7	0	0	0	0		0	0	0	0	0
4 Order Material	1.4	40,207	7	0	0	0	0		0	0	0	0	0
5 Go to Storeroom or Check Computer to See if Stores Have it	2.2	63,182	11	0	0	0	0		0	0	0	0	0
8 Pick up Materials	2.2	63,182	11	0	0	0	0		0	0	0	0	0
Activity Total	7.9	238,084	40	1	0	0	0						
		0	0.0%	0.0%				0.0%	0	0	0	0	0

Activity **18-04**

Handle Waste Material

Activity Note

Activity Driver Candidates Production

	FTE	Cost	People Time	Maintane nce (In	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Check Tank and Dike Area for Waste Oil	0.4	11,488	2	0	0	0	0	100	100	0	0	0	0
2 Collect Waste Oil Sample and Test	1.2	34,463	6	0	0	0	0	100	0	0	0	100	0
3 Check and Dispose of Waste Material	0.4	19,817	2	1	0	0	0	100	0	0	0	100	0
4 Replace Oil or Lubrication	1.0	37,049	5	1	0	0	0	25	12.5	0	0	12.5	0
5 Waste Oil Put in 50 Gal Drums & Sold to Outside Sources	0.0		0	0	0	0	0		0	0	0	0	0
7 Drain Equipment Oil	2.6	83,000	13	1	0	0	0	20	10	0	0	10	0
Activity Total	5.5	185,817	28	3	0	0	0						
		91,630	49.5%	48.3%				49.3%	24,419	0	0	67,212	0

Activity **18-05**

Prepare for Jobs

Activity Note

Activity Driver Candidates Produciton

	FTE	Cost	People Time	Maintane nce (In	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Check Job Sites	1.6	45,951	8	0	0	0	0	5	5	0	0	0	0
3 Fill Out Safety Inspection Sheets	0.2	5,744	1	0	0	0	0		0	0	0	0	0

	FTE	Cost	People Time	Maintane nce (In	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
4 Determine if Safety Man is Required to Inspect Job Site	0.4	11,488	2	0	0	0	0		0	0	0	0	0
5 Determine Who has Skills to do Certain Job	0.0		0	0	0	0	0		0	0	0	0	0
6 Split up into Groups To Do More Than One Job	0.0		0	0	0	0	0		0	0	0	0	0
7 Inspect Jobs to Determine What Needs to be Done	0.2	5,744	1	0	0	0	0		0	0	0	0	0
8 Check w/ Forman in Operations to Determine What Needs to be Done First	0.0		0	0	0	0	0		0	0	0	0	0
9 Check w/ Lead Operators	0.4	11,488	2	0	0	0	0		0	0	0	0	0
Activity Total	2.8	80,414	14	0	0	0	0						
		2,298	2.9%					2.9%	2,298	0	0	0	0

Activity **18-06**

Manage Paperwork

				Activity Driver Candidates	Activity Note		Facility						
	FTE	Cost	People Time	Maintane nce (In	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Time Sheets	1.5	43,079	7.5	0	0	0	0		0	0	0	0	0
2 Establish Jobs and Work Orders	1.2	34,463	6	0	0	0	0		0	0	0	0	0
3 Check Schedule and Jobs	0.1	2,872	0.5	0	0	0	0		0	0	0	0	0
4 Attend Planning Meetings	0.2	5,744	1	0	0	0	0	5	5	0	0	0	0
5 Job Scopes	0.3	8,616	1.5	0	0	0	0		0	0	0	0	0
7 Schedule Work Load	0.1	2,872	0.5	0	0	0	0		0	0	0	0	0
8 Check Telephone Messages	0.1	2,872	0.5	0	0	0	0		0	0	0	0	0
9 Check Trouble Spots	0.1	2,872	0.5	0	0	0	0		0	0	0	0	0
11 Prioritize Jobs	0.4	11,488	2	0	0	0	0		0	0	0	0	0
12 Receive Job Work Orders	1.2	34,463	6	0	0	0	0		0	0	0	0	0
13 Get Permit If Required	0.4	11,488	2	0	0	0	0		0	0	0	0	0
14 Check Work Orders	1.1	31,591	5.5	0	0	0	0	5	5	0	0	0	0
Activity Total	6.6	192,419	33.5	0	0	0	0						
		1,867	1.0%					1.0%	1,867	0	0	0	0

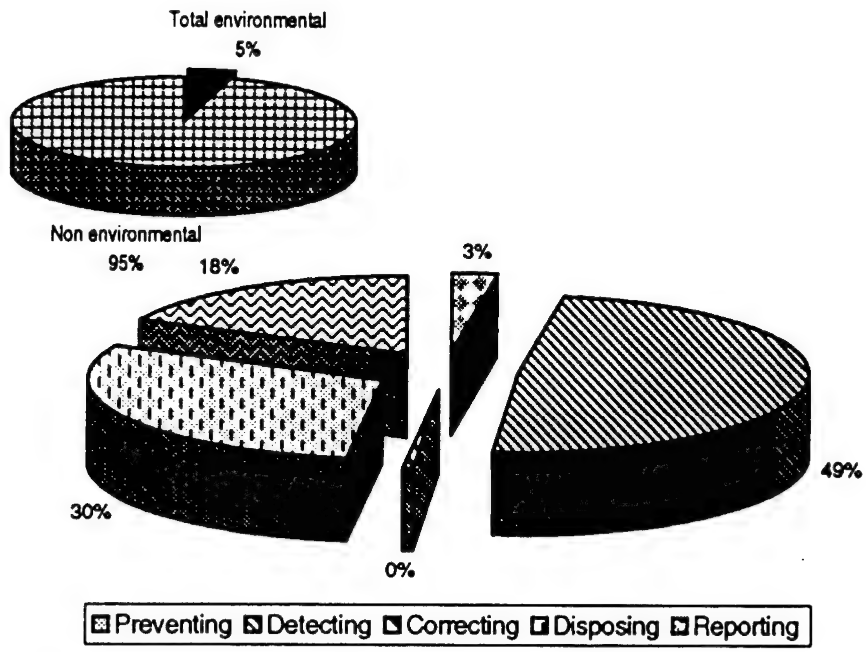
Activity **18-07**

Train Personnel

				Activity Driver Candidates	Activity Note		Facility						
	FTE	Cost	People Time	Maintane nce (In	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
2 Regulatory Training	0.4	11,488	2	0	0	0	0	25	25	0	0	0	0
4 Skill Training	0.4	11,488	2	0	0	0	0	20	20	0	0	0	0
5 Record Keeping	0.9	34,177	4.5	1	0	0	0	30	0	0	0	0	30
6 Mandatory Safety Training	1.6	45,951	8	0	0	0	0	30	30	0	0	0	0

7 Safety Meetings	1.8	60,024	9	1	0	0	0	30	30	0	0	0	0
Activity Total	5.0	163,127	25.5	2	0	0	0						
		47,215	28.8%	30.0%				28.9%	36,962	0	0	0	10,253
Session Total	63.0	2,004,625	320	20	0	0	0						
		298,723	13.8%	27.3%					198,944	0	0	89,526	10,253

Employee Benefits/Personnel Services/Admin Service



Session Number	19
Group	Employee Benefits/Personnel Services/Admin Service
Organization	Support

Category	Cost	% of Total	% of Environmental
Preventing	761	0.1%	2.6%
Detecting	14,186	2.2%	48.8%
Correcting	142	0.0%	0.5%
Disposing	8,752	1.4%	30.1%
Reporting	5,237	0.8%	18.0%
Total environmental	29,078	4.6%	100.0%
Non environmental	609,771	95.4%	
Cost	638,849	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
19	Employee Benefits/Personnel Services/Admin Service								
19-01	Manage Government Property	212	301	35	1,460	336	2,345	77,131	3.0%
19-02	Attend Training Sessions	513	0	0	0	0	513	21,232	2.4%
19-03	Administer Emploee Benefit Programs/Plans	0	0	0	0	0	0	206,725	0.0%
19-04	Provide Personnel Services	0	0	0	0	0	0	102,621	0.0%
19-05	Support Process Improvement	0	0	106	0	35	142	17,693	0.8%
19-06	Maintain Facility Inventory	0	0	0	4,991	0	4,991	53,063	9.4%
19-07	Purchase Operating Supplies	35	0	0	0	0	35	22,985	0.2%
19-08	Provide Printing Services	0	0	0	531	0	531	17,693	3.0%
19-09	Respond to Government Requests	0	0	0	0	4,335	4,335	23,001	18.8%
19-10	Manage Daily Activities	0	13,886	0	1,769	531	16,186	96,703	16.7%
Subtotal Employee Benefits/Personnel Servic		761	14,186	142	8,752	5,237	29,078	638,849	4.6%

Holston Activity and Task Summary

Session 19 Employee Benefits/Personnel Services/Adm

Date 8/11/97 6 Participants Ron Gentry, Sandy Greene, James Henderson, Tom Mills, Gordon Porter Observers Ennis, Glenn, Keith, Mark, Alan, Ross

Time 1:00 FTE: 15 129 Years Experience Note

Activity **19-01**

Manage Government Property

Activity Note

Activity Driver Candidates Facility

	FTE	Cost	People Time	Maintanence	Operating Supplies	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Property Reports	0.1	11,974	1.5	0	2	0	0	2	0	0	0	2	0
2 Equip, Download to Scrap, Landfill, or Burning Ground	0.2	7,077	2	0	0	0	0	5	2.5	0	0	2.5	0
3 Issue HOL Numbers for Equipment	0.1	3,436	0.5	0	0.5	0	0		0	0	0	0	0
4 Excess Property	0.2	7,077	2	0	0	0	0	10	0	0	0	10	0
5 Charge-off Contractor Jobs	0.1	3,539	1	0	0	0	0		0	0	0	0	0
6 Screen Equipment	0.1	3,539	1	0	0	0	0		0	0	0	0	0
7 Donate Property	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
8 Free Issue	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
10 Correct Codes on Equipment	0.1	3,539	1	0	0	0	0		0	0	0	0	0
11 Property Administrator	0.2	7,077	2	0	0	0	0		0	0	0	0	0
12 Answer Ques. On Purchasability of Capital Equipment	0.1	3,539	1	0	0	0	0		0	0	0	0	0
13 Keep up w/ Army Regulations Concerning Property	0.1	1,769	0.5	0	0	0	0	10	2	2	2	2	2
14 Holstein Def Corp Sales	0.2	10,410	2	0	1	0	0		0	0	0	0	0
15 Disposal of Bldgs	0.1	1,769	0.5	0	0	0	0	45	0	15	0	15	15
16 Journal Entries for Accoutning	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
17 Update Real Property Inventory to Send to IOC	0.1	1,769	0.5	0	0	0	0	4	0	0	0	2	2
18 Computer Entries on Records of Property	0.1	5,308	1.5	0	0	0	0		0	0	0	0	0
Activity Total	1.9	77,131	18.5	0	3.5	0	0						
		2,345	3.4%		1.1%			3.0%	212	301	35	1,460	336

Activity **19-02**

Attend Training Sessions

Activity Note

Activity Driver Candidates Facility

	FTE	Cost	People Time	Maintanence	Operating Supplies	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Check Out Training Materials and Equipment	0.3	12,385	3.5	0	0	0	0		0	0	0	0	0
2 Training Sessions at Rock Island about Once a Year	0.1	1,769	0.5	0	0	0	0	5	5	0	0	0	0
3 Attend Safety, Env. Coord., and VE Stat Meetings	0.1	5,308	1.5	0	0	0	0	8	8	0	0	0	0

Task	FTE	Cost	People Time	Maintenance	Operating Supplies	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
4 Attend Monthly Safety Meetings	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.6	21,232	6	0	0	0	0						
		513	2.4%					2.4%	513	0	0	0	0

Activity **19-03**

Administer Emploee Benefit Programs/

				Activity Note									
				Activity Driver Candidates			Facility						
	FTE	Cost	People Time	Maintane nce	Operatin g Supplies	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Administer Worker Compensation/Long-Term Disability and Other Benefits Plans	1.4	59,541	14	0	3	0	0		0	0	0	0	0
2 Prepare Employee Benefit (EB) Communications	0.3	20,615	3	0	3	0	0		0	0	0	0	0
3 Calculate Retiree Benefits	0.2	10,410	2	0	1	0	0		0	0	0	0	0
4 Prepare Various Reports for IRS & Others Regarding Benefits Programs/Funds/Trust	1.0	38,720	10	0	1	0	0		0	0	0	0	0
5 Consult Employees about Insurance/Retirement Plans, etc.	1.1	42,258	11	0	1	0	0		0	0	0	0	0
6 Supervise/Manage EB Function	0.7	24,771	7	0	0	0	0		0	0	0	0	0
7 Maintain Plan Documents	0.2	10,410	2	0	1	0	0		0	0	0	0	0
Activity Total	4.9	206,725	49	0	10	0	0						
		0	0.0%		0.0%			0.0%	0	0	0	0	0

Activity **19-04**

Provide Personnel Services

				Activity Note									
				Activity Driver Candidates			Production						
	FTE	Cost	People Time	Maintane nce	Operatin g Supplies	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Estimate Labor Requirements	0.3	10,616	3	0	0	0	0		0	0	0	0	0
2 Advise Management and Employees on Authorized Procedures	0.2	7,077	2	0	0	0	0		0	0	0	0	0
3 Hire New Employees	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
4 Coordinate RIF Procedures	0.3	8,847	2.5	0	0	0	0		0	0	0	0	0
5 Conduct Job Studies	0.3	10,616	3	0	0	0	0		0	0	0	0	0
6 Coordinate Equal Opportunity Employment Program	0.1	3,539	1	0	0	0	0		0	0	0	0	0
7 Administer Salary/Compensation Programs	1.4	49,541	14	0	0	0	0		0	0	0	0	0
8 Prepare Papers to Transfer & Reclassify Employees	0.2	7,077	2	0	0	0	0		0	0	0	0	0
9 Coordniate Food/Vending Services	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
10 Coordinate Recreation Program	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0

	FTE	Cost	People Time	Maintanence	Operating Supplies	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
Activity Total	2.9	102,621	29	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **19-05**

Support Process Improvement

				Activity Note									
				Activity Driver Candidates			Production						
	FTE	Cost	People Time	Maintane nce	Operatin g Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Process Value Engineering(VE) Submissions, Handle Correspondence on VE Program	0.3	10,616	3	0	0	0	0	1	0	0	1	0	0
2 Present VE Status	0.1	3,539	1	0	0	0	0	1	0	0	0	0	1
3 Perform Statistical Analysis	0.1	3,539	1	0	0	0	0		0	0	0	0	0
Activity Total	0.5	17,693	5	0	0	0	0						
		142	0.8%					0.8%	0	0	106	0	35

Activity **19-06**

Maintain Facility Inventory

				Activity Note									
				Activity Driver Candidates			Production						
	FTE	Cost	People Time	Maintane nce	Operatin g Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Inventory Reproduciton Supplies, Order as Needed	0.1	14,344	1	1	2	0	0	25	0	0	0	25	0
2 Inventory all Magazines (Storage of Chemicals, Explosives, etc.)	0.1	3,539	1	0	0	0	0		0	0	0	0	0
3 Inventory all Property, Equipment at HDC	0.7	28,104	7	0	1	0	0	5	0	0	0	5	0
4 Inventory Weapons and Ammunition	0.1	3,539	1	0	0	0	0		0	0	0	0	0
5 Computer Entry for Property Recording System after each Inventory	0.1	3,539	1	0	0	0	0		0	0	0	0	0
Activity Total	1.1	53,063	11	1	3	0	0						
		4,991	5.5%	25.0%	18.3%			9.4%	0	0	0	4,991	0

Activity **19-07**

Purchase Operating Supplies

				Activity Note									
				Activity Driver Candidates			Production						
	FTE	Cost	People Time	Maintane nce	Operatin g Supplies	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 LBO Office Supplies	0.1	3,436	0.5	0	0.5	0	0		0	0	0	0	0
2 Write Purchase Orders for Admin Services Contracts-Copiers, Typewriters, etc.	0.1	5,908	0.5	1	0	0	0		0	0	0	0	0
3 Misc. Purchase Requisitions for Government	0.1	3,436	0.5	0	0.5	0	0		0	0	0	0	0
4 Payment of Magazines, Books Memberships	0.1	1,769	0.5	0	0	0	0	2	2	0	0	0	0

Holston Activity and Task Summary

Session 19 Employee Benefits/Personnel Services/Adm

Task	FTE	Cost	People Time	Maintance	Operating Supplies	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
5 Order Supplies for Stationery Stock	0.1	8,436	0.5	0	2	0	0		0	0	0	0	0
Activity Total	0.3	22,985	2.5	1	3	0	0						
		35	0.4%	0.0%	0.0%			0.2%	35	0	0	0	0

Activity **19-08**

Provide Printing Services

Activity Note

Activity Driver Candidates Production

	FTE	Cost	People Time	Maintance	Operating Supplies	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Make-up Monthly Reproduction Report at End of Each Month	0.1	3,539	1	0	0	0	0		0	0	0	0	0
2 Reproduce Forms, Reports on Offset Press	0.3	10,616	3	0	0	0	0	5	0	0	0	5	0
3 Operate Folder/Lableing Machine	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
4 Furnish Copy Paper for Copies in Other Locations Throughout Plant	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.5	17,693	5	0	0	0	0						
		531	3.0%					3.0%	0	0	0	531	0

Activity **19-09**

Respond to Government Requests

Activity Note

Activity Driver Candidates Facility

	FTE	Cost	People Time	Maintance	Operating Supplies	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Prepare Input to Environmental Reports (SARA 312,313, SPCC Plan)	0.1	3,539	1	0	0	0	0	100	0	0	0	0	100
2 Respond to Government Letters, Audits, etc.	0.3	10,616	3	0	0	0	0	5	0	0	0	0	5
3 Government Reports Due at Headquarters	0.3	8,847	2.5	0	0	0	0	3	0	0	0	0	3
Activity Total	0.7	23,001	6.5	0	0	0	0						
		4,335	18.8%					18.8%	0	0	0	0	4,335

Activity **19-10**

Manage Daily Activities

Activity Note

Activity Driver Candidates Facility

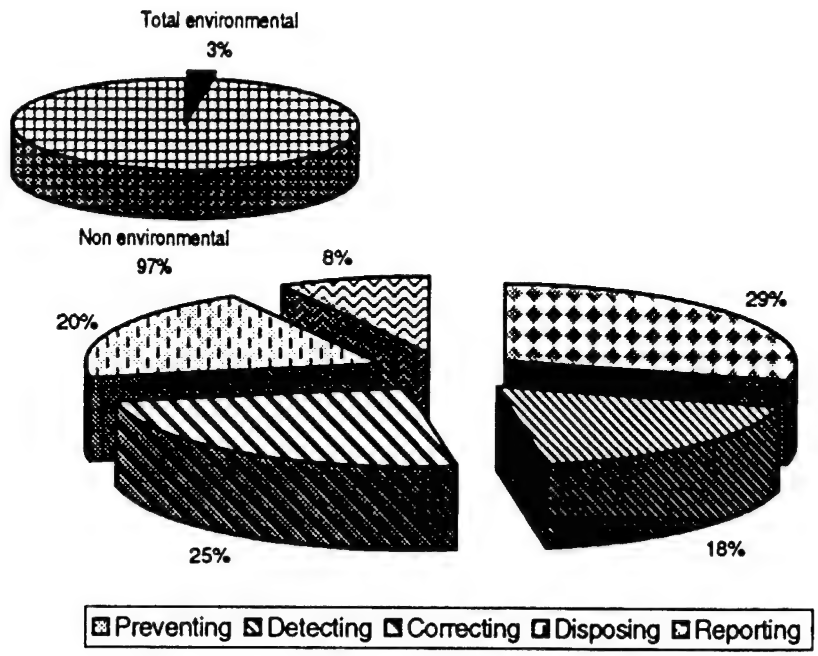
	FTE	Cost	People Time	Maintance	Operating Supplies	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Check Task Calendar	0.6	19,463	5.5	0	0	0	0	2	0	0	0	0	2
6 Check Box at Government Staff for Email for Joe	0.0		0	0	0	0	0		0	0	0	0	0
7 Update Time Log	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
8 Check w/ Supervisors for Tasks	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
9 Check Incoming Work Orders	0.1	3,539	1	0	0	0	0		0	0	0	0	0
10 Pick up and Distribute Mail	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
11 Go to Post Office at 3:50 p.m.	0.1	3,539	1	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 19 Employee Benefits/Personnel Services/Adm

12 Update HDC Authorized Procedures	0.4	14,155	4	0	0	0	0	1	0	0	0	0	1
13 Responsible for Maintanence Upkeep, Sched Repair Work for Copier, Calc, Typewrtr	0.1	10,047	0.5	2	0	0	0		0	0	0	0	0
14 Prepare Reactivation Networks	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
15 Coord Between Defnse Revitalization Marketing Office (DRMO) & Gov't on Haz Waste	0.1	1,769	0.5	0	0	0	0	100	0	0	0	100	0
16 Oversee Fire, Security, Admin Services Dept.	0.0		0	0	0	0	0		0	0	0	0	0
17 Responsible for Maintanence of Bldg 26	0.0	14,486	0	3.5	0	0	0		0	0	0	0	0
18 Check HVAC System	0.1	13,886	1	2.5	0	0	0	100	0	100	0	0	0
19 Charge of People Moving Offices	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
20 Check Mailbox in Accounting for Purchase Orders	0.1	1,769	0.5	0	0	0	0		0	0	0	0	0
21 HDC Correspondences for Security, Fire, Admin Services	0.1	5,205	1	0	0.5	0	0		0	0	0	0	0
22 Voice Mail	0.0		0	0	0	0	0		0	0	0	0	0
Activity Total	1.8	96,703	17.5	8	0.5	0	0						
		16,186	9.4%	31.3%	0.0%			16.7%	0	13,886	0	1,769	531
Session Total	15.0	638,849	150	10	20	0	0						
		29,078	3.0%	27.5%	3.0%				761	14,186	142	8,752	5,237

Purchasing



Session Number	20		
Group	Purchasing		
Organization	Support		

Category	Cost	% of Total	% of Environmental
Preventing	2,185	0.8%	29.0%
Detecting	1,382	0.5%	18.3%
Correcting	1,866	0.7%	24.7%
Disposing	1,477	0.5%	19.6%
Reporting	635	0.2%	8.4%
Total environmental	7,545	2.6%	100.0%
Non environmental	278,452	97.4%	
Cost	285,997	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
20	Purchasing								
20-01	Comply w/ Rules and Regulations	0	0	0	0	0	0	22,244	0.0%
20-02	Subcontract Goods and Services	0	715	715	254	0	1,684	84,210	2.0%
20-03	Procure Goods and Services	2,185	667	1,151	1,223	635	5,861	146,176	4.0%
20-04	Certify Vendors	0	0	0	0	0	0	12,711	0.0%
20-05	Attend Meetings	0	0	0	0	0	0	7,944	0.0%
20-06	Maintain Purchasing	0	0	0	0	0	0	12,711	0.0%
Subtotal Purchasing		2,185	1,382	1,866	1,477	635	7,545	285,997	2.6%

Holston Activity and Task Summary

Session 20 Purchasing

Date 8/12/97 | 3 Participants | John Caldwell, Carol Benge, Pat Jones | Observers | Ennis, Glenn, Keith, Mark, Alan, Ross

Time 8:00 | FTE: | 9 58 Years Experience | Note

Activity **20-01**

Comply w/ Rules and Regulations

Activity Note: Activity Driver Candidates Facility

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Contractor Purchasing Systems Review (CPSR) (Audit Team)	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
2 Respond to Auditors	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
3 Disaduantaged Business Enterprise Report	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
4 SF294 & SF295 Small Business Report	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
5 Report Sourcing for Recycled Materials for Purchase	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
6 Labor Standards Interview Reports	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
7 Update Purchasing Manual	0.1	4,767	1.5	0	0	0	0		0	0	0	0	0
8 Locate Small Disadvantaged Business (SDB)/Women Owned (WO)	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
9 Maintain Updated Listing of Davis-Bacon Regulations/Rates	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
10 Revise Purchase Order Forms	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
11 Small Business Plan	0.1	3,178	1	0	0	0	0		0	0	0	0	0
Activity Total	0.7	22,244	7	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **20-02**

Subcontract Goods and Services

Activity Note: Activity Driver Candidates Production

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Prepare Invitation for Bid Pkg	0.3	9,533	3	0	0	0	0	15	0	7.5	7.5	0	0
2 Route PO/Subcontract for Review	0.1	3,178	1	0	0	0	0		0	0	0	0	0
3 Train Subcontract Administrators	0.2	6,355	2	0	0	0	0		0	0	0	0	0
4 Changes to Subcontracts (Admendments)	0.2	6,355	2	0	0	0	0		0	0	0	0	0
5 Award Subcontract	0.4	12,711	4	0	0	0	0	2	0	0	0	2	0
6 Prepare Subcontract	0.4	12,711	4	0	0	0	0		0	0	0	0	0
7 Visit Job Site for Review of Progress	0.1	3,178	1	0	0	0	0		0	0	0	0	0
8 Post Award Meeting	0.3	9,533	3	0	0	0	0		0	0	0	0	0
9 Review Request for Payment on Subcontract	0.1	3,178	1	0	0	0	0		0	0	0	0	0
10 White Paper Subcontracts	0.2	6,355	2	0	0	0	0		0	0	0	0	0
11 Setup Job Showings	0.2	6,355	2	0	0	0	0		0	0	0	0	0

12 Preliminary MTG to Prepare for Job Show	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
13 Subcontract Performance Review (@ Completion of Job)	0.1	3,178	1	0	0	0	0		0	0	0	0	0
Activity Total	2.7	84,210	26.5	0	0	0	0						
		1,684	2.0%					2.0%	0	715	715	254	0

Activity **20-03**

Procure Goods and Services

	FTE	Cost	People Time	Activity Driver Candidates -	Activity Note -	-	Facility -	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Review PO's	0.1	4,767	1.5	0	0	0	0		0	0	0	0	0
2 Bid Review	0.1	3,178	1	0	0	0	0		0	0	0	0	0
3 Send Out RFQ	0.3	11,122	3.5	0	0	0	0	15	6	6	0	3	0
4 Training on Computer & Purchasing Process	0.0		0	0	0	0	0		0	0	0	0	0
5 Documentation	0.3	7,944	2.5	0	0	0	0		0	0	0	0	0
6 Telephone Purchase Items as Requestor LBO	0.7	20,655	6.5	0	0	0	0	5	2.5	0	2.5	0	0
7 MRO Buying	0.6	19,066	6	0	0	0	0	5	5	0	0	0	0
8 File PO	0.1	4,767	1.5	0	0	0	0		0	0	0	0	0
9 Cert. Of Raw Materials Each Shipment	0.1	3,178	1	0	0	0	0		0	0	0	0	0
10 Surplus Sales	0.1	1,589	0.5	0	0	0	0	10	0	0	0	10	0
11 Negotiation	0.3	11,122	3.5	0	0	0	0		0	0	0	0	0
12 Prepare Requisitions for Purchasing Dept. Needs	0.1	3,178	1	0	0	0	0		0	0	0	0	0
13 Fact Gathering Time	0.1	4,767	1.5	0	0	0	0	1	1	0	0	0	0
14 Rec. Requisition & Purasign	0.1	3,178	1	0	0	0	0		0	0	0	0	0
15 Bid Opening	0.1	4,767	1.5	0	0	0	0		0	0	0	0	0
16 Respond to Inventory Computer Run	0.2	6,355	2	0	0	0	0		0	0	0	0	0
17 Contact Vendor/HDC Rep on Problems	0.3	9,533	3	0	0	0	0	20	0	0	6.66	6.66	6.66
18 Contact Requisition for Verification of Need	0.2	6,355	2	0	0	0	0		0	0	0	0	0
19 Input in Computer	0.5	14,300	4.5	0	0	0	0		0	0	0	0	0
20 Talk w/ Eng. About Job/Specifications	0.1	4,767	1.5	0	0	0	0	2	0	0	0	2	0
21 Review Purchase REQ	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
Activity Total	4.6	146,176	46	0	0	0	0						
		5,861	4.0%					4.0%	2,185	667	1,151	1,223	635

Holston Activity and Task Summary

Session 20 Purchasing

Activity **20-04**

Certify Vendors

				Activity Note									
				Activity Driver Candidates			Facility						
	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Certify Vendors	0.2	6,355	2	0	0	0	0		0	0	0	0	0
2 Respond to Vendor Request for Certification	0.0		0	0	0	0	0		0	0	0	0	0
3 Cert. Of Insurance	0.1	3,178	1	0	0	0	0		0	0	0	0	0
4 Evaluate Vendor Cert. Forms	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
5 Select Group of Qualified Vendors for RFQ	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.4	12,711	4	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **20-05**

Attend Meetings

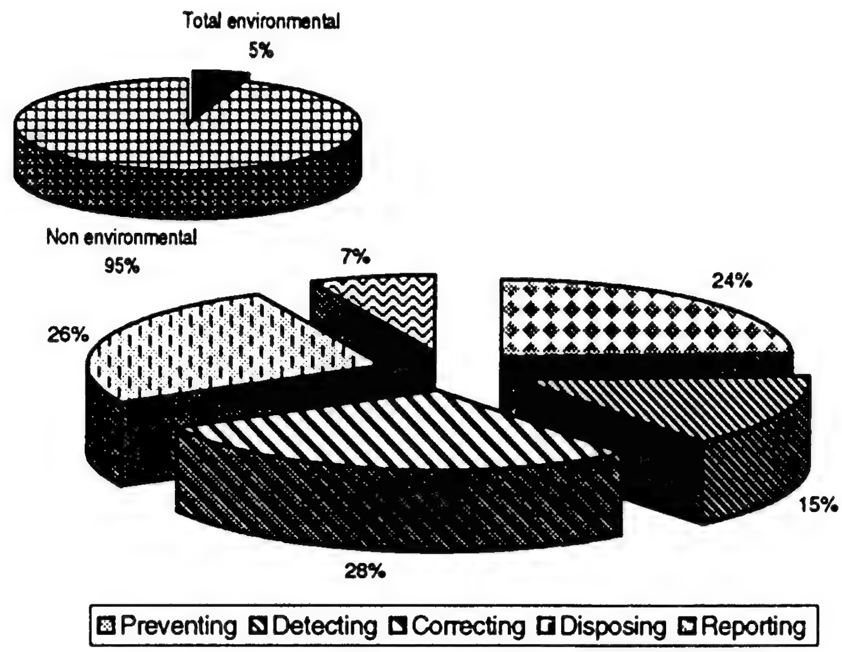
				Activity Note									
				Activity Driver Candidates			Facility						
	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Team Meetings	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
2 Safety Meetings	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
3 Administer Safety Meetings	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
4 Business Mgt. Meetings	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
5 Sales People Meetings	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.3	7,944	2.5	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **20-06**

Maintain Purchasing

				Activity Note									
				Activity Driver Candidates			Facility						
	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Performance Charts	0.2	6,355	2	0	0	0	0		0	0	0	0	0
2 Payroll Info	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
3 Repairs, Contract Data (Comp), Copy Mach., Tele, etc.	0.1	1,589	0.5	0	0	0	0		0	0	0	0	0
4 Purge Files Yearly	0.1	3,178	1	0	0	0	0		0	0	0	0	0
Activity Total	0.4	12,711	4	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0
Session Total	9.0	285,997	90	0	0	0	0						
		7,545	2.6%						2,185	1,382	1,866	1,477	635

HDC Management Team



Session Number	21		
Group	HDC Management Team		
Organization	Support		

Category	Cost	% of Total	% of Environmental
Preventing	10,465	1.2%	24.2%
Detecting	6,424	0.8%	14.9%
Correcting	12,141	1.4%	28.1%
Disposing	11,206	1.3%	25.9%
Reporting	2,975	0.4%	6.9%
Total environmental	43,210	5.2%	100.0%
Non environmental	794,784	94.8%	
Cost	837,995	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
21	HDC Management Team								
21-01	Plan Operations	3,910	2,514	3,910	3,910	2,514	16,758	192,739	8.7%
21-02	Monitor Results of Plans	6,068	1,396	5,230	4,295	461	17,450	284,918	6.1%
21-03	Manage Operations	487	2,514	3,001	3,001	0	9,003	360,338	2.5%
Subtotal HDC Management Team		10,465	6,424	12,141	11,206	2,975	43,210	837,995	5.2%

Holston Activity and Task Summary

Session 21 HDC Management Team

Date 8/12/97 | 6 Participants | Dick Bacon, Richard Gillenwater, Phil Ketron, Alan King, Everett Mechem | Observers | Ennis, Glenn, Keith, Mark, Alan, Ross

Time 1:00 | FTE: | 11 133 Years Experience | Note

Activity **21-01**

Plan Operations

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Plan	0.7	50,280	6	0	0	0	0	10	2	2	2	2	2
2 Plan Budgets	0.2	16,760	2	0	0	0	0	2	1	0	1	0	0
3 Plan Staffing	0.2	16,760	2	0	0	0	0	3	0	1	0	1	1
4 Lead Meetings	0.3	25,140	3	0	0	0	0	10	2	2	2	2	2
5 Direction	0.4	33,520	4	0	0	0	0	10	2	2	2	2	2
6 Develop Personnel	0.2	16,760	2	0	0	0	0		0	0	0	0	0
7 Communicate HDC Strategy & Monitor Actions to Comply	0.2	16,760	2	0	0	0	0	5	1	1	1	1	1
8 Meet w/ Dept. Heads to Review Problems & Plan Future Actions	0.1	8,380	1	0	0	0	0		0	0	0	0	0
9 Deal "Politically" w/ HSAAP Gov't Staff	0.1	8,380	1	0	0	0	0	50	16.66	0	16.66	16.66	0
10 Consult w/ Eastman on RR Bridges	0.0		0	0	0	0	0		0	0	0	0	0
Activity Total	2.5	192,739	23	0	0	0	0						
		16,758	8.7%					8.7%	3,910	2,514	3,910	3,910	2,514

Activity **21-02**

Monitor Results of Plans

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Envrionmental Review Meeting	0.1	8,380	1	0	0	0	0	100	33.3	0	33.3	33.3	0
2 Audit Performance-Safety, Production, Environmental	0.2	16,760	2	0	0	0	0	25	8.33	8.33	8.33	0	0
4 Obtain Feedback from Internal Customers	0.0		0	0	0	0	0		0	0	0	0	0
5 Weekend Duty- Deal w/ Emergencies	0.0		0	0	0	0	0		0	0	0	0	0
6 Review Cost Reports	0.0		0	0	0	0	0		0	0	0	0	0
7 Review Landfill Operations	0.0		0	0	0	0	0		0	0	0	0	0
8 Review/Approve SOP's	0.1	4,190	0.5	0	0	0	0	10	10	0	0	0	0
9 Review/Approve "Process Changes"	0.1	4,190	0.5	0	0	0	0	10	10	0	0	0	0
10 Review Safety Incident Report for Yesterday	0.1	4,190	0.5	0	0	0	0		0	0	0	0	0
11 Monitor Results	1.2	92,179	11	0	0	0	0	1	0	0	0	0.5	0.5
12 Review Monthly Discharge Monitoring Report (DMR)	0.0		0	0	0	0	0		0	0	0	0	0

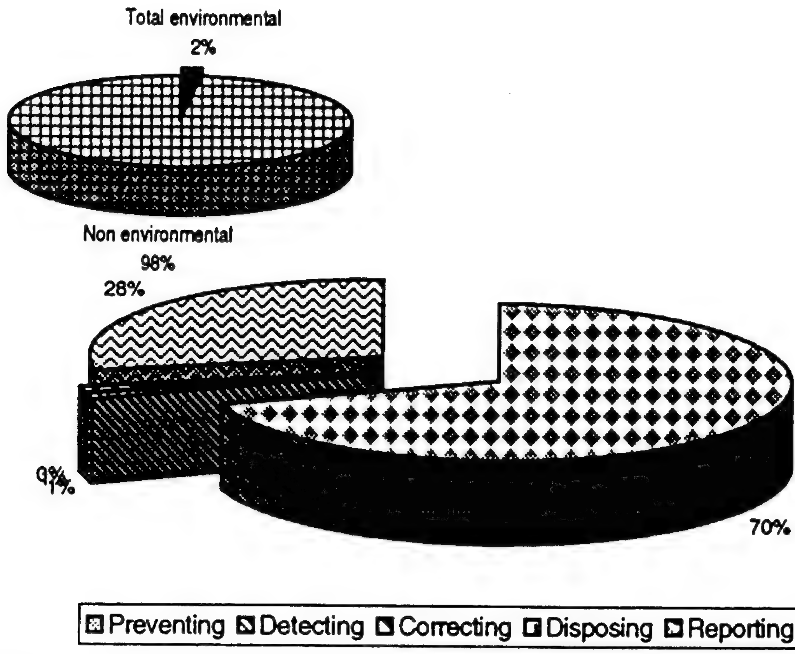
13 Customers-Purchases, Tech. Questions, Product Info.	0.0		0	0	0	0	0		0	0	0	0	0
14 Maintain Records	1.2	92,179	11	0	0	0	0		0	0	0	0	0
15 Collect Facts/Opinions	0.8	62,850	7.5	0	0	0	0	5	1.66	0	1.66	1.66	0
Activity Total	3.7	284,918	34	0	0	0	0						
		17,450	6.1%					6.1%	6,068	1,396	5,230	4,295	461

Activity **21-03**

Manage Operations

				Activity Driver Candidates			Activity Note						
	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Negotiate	0.7	50,280	6	0	0	0	0		0	0	0	0	0
2 Review Invoices	0.3	25,140	3	0	0	0	0		0	0	0	0	0
3 Write Procedures	0.0		0	0	0	0	0		0	0	0	0	0
4 Review, Edit, and Approve Documents	0.4	29,330	3.5	0	0	0	0	5	1.66	0	1.66	1.66	0
5 Assess Performance	0.1	4,190	0.5	0	0	0	0		0	0	0	0	0
6 Answer Questions	0.8	58,660	7	0	0	0	0		0	0	0	0	0
7 Types of Ques:Plant Hist, Previous Oper, Wage Issues, Tech. Issues	0.0		0	0	0	0	0		0	0	0	0	0
8 Process Information	0.9	67,040	8	0	0	0	0		0	0	0	0	0
9 Provide Resources	0.1	8,380	1	0	0	0	0		0	0	0	0	0
10 Identify Risks	0.2	16,760	2	0	0	0	0	30	0	10	10	10	0
11 Dispense Reality	0.1	8,380	1	0	0	0	0		0	0	0	0	0
12 Talk to Customers	0.1	8,380	1	0	0	0	0		0	0	0	0	0
13 Influence	0.3	25,140	3	0	0	0	0		0	0	0	0	0
14 Inform Shareholder	0.1	8,380	1	0	0	0	0	30	0	10	10	10	0
15 Deal w/ Personnel Issues/Problems	0.1	8,380	1	0	0	0	0		0	0	0	0	0
16 Respond to Community Complaints	0.0		0	0	0	0	0		0	0	0	0	0
17 Administer Benefits	0.6	41,900	5	0	0	0	0		0	0	0	0	0
Activity Total	4.7	360,338	43	0	0	0	0						
		9,003	2.5%					2.5%	487	2,514	3,001	3,001	0
Session Total	11.0	837,995	100	0	0	0	0						
		43,210	5.2%						10,465	6,424	12,141	11,206	2,975

Financial Services & Payroll



Session Number 22
Group Financial Services & Payroll
Organization Support

Category	Cost	% of Total	% of Environmental
Preventing	6,435	1.4%	69.8%
Detecting	98	0.0%	1.1%
Correcting	98	0.0%	1.1%
Disposing	-	0.0%	0.0%
Reporting	2,590	0.6%	28.1%
Total environmental	9,221	2.0%	100.0%
Non environmental	461,650	98.0%	
Cost	470,871	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
22	Financial Services & Payroll								
22-01	Analyze Accounts	0	0	0	0	0	0	43,163	0.0%
22-02	Process Payroll	3,728	0	0	0	0	3,728	113,794	3.3%
22-03	Pay Bills	1,079	0	98	0	1,177	2,354	70,631	3.3%
22-04	Respond to Auditors	0	98	0	0	0	98	21,582	0.5%
22-05	Prepare Reports	0	0	0	0	432	432	51,011	0.8%
22-06	Close Monthly	0	0	0	0	392	392	60,821	0.6%
22-07	Estimate Costs	687	0	0	0	490	1,177	47,087	2.5%
22-08	Develop Software	0	0	0	0	98	98	13,734	0.7%
22-09	Manage Teams	942	0	0	0	0	942	49,049	1.9%
Subtotal Financial Services & Payroll		6,435	98	98	0	2,590	9,221	470,871	2.0%

Holston Activity and Task Summary

Session 22 Financial Services & Payroll

Date 8/13/97	6 Participants	Gayle Caldwell, Tina Seaver, Don Neff, Jim Kendrick, Jim Blalock, Jim White	Observers: Ennis, Glenn, Keith, Mark, Alan, Ross
Time 8:00	FTE:	12 134 Years Experience	Note

Activity **22-01**

Analyze Accounts

Activity Note

Activity Driver Candidates: Facility

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Identify Problems	0.1	5,886	1.5	0	0	0	0		0	0	0	0	0
2 Account Analysis	0.1	3,924	1	0	0	0	0		0	0	0	0	0
3 Correct OP Errors	0.4	15,696	4	0	0	0	0		0	0	0	0	0
4 Account Recociliations	0.1	3,924	1	0	0	0	0		0	0	0	0	0
5 Update Chart of Accounts	0.2	7,848	2	0	0	0	0		0	0	0	0	0
6 Cost Reviews	0.1	3,924	1	0	0	0	0		0	0	0	0	0
7 Analyze Cost & Pricing Data Subcontractors	0.1	1,962	0.5	0	0	0	0		0	0	0	0	0
Activity Total	1.1	43,163	11	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **22-02**

Process Payroll

Activity Note

Activity Driver Candidates: Production Volume

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Pay People	1.9	74,555	19	0	0	0	0	5	5	0	0	0	0
2 Bonds	0.1	1,962	0.5	0	0	0	0		0	0	0	0	0
3 Credit Union	0.1	5,886	1.5	0	0	0	0		0	0	0	0	0
4 Benefits Reports	0.5	19,620	5	0	0	0	0		0	0	0	0	0
5 Tax Report (Payroll)	0.3	11,772	3	0	0	0	0		0	0	0	0	0
Activity Total	2.9	113,794	29	0	0	0	0						
		3,728	3.3%					3.3%	3,728	0	0	0	0

Activity **22-03**

Pay Bills

Activity Note

Activity Driver Candidates: Production Volume

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Prepare Travel Requests-Expense Statements	0.1	3,924	1	0	0	0	0	5	0	0	2.5	0	2.5
2 Accounts Payable	1.1	43,163	11	0	0	0	0	5	2.5	0	0	0	2.5
3 Materials Inventory	0.1	1,962	0.5	0	0	0	0		0	0	0	0	0
4 Process LBO Check Register-Under Register	0.1	5,886	1.5	0	0	0	0		0	0	0	0	0

5 End of Year Accruals	0.0		0	0	0	0	0		0	0	0	0	0
6 Cash Report	0.1	1,962	0.5	0	0	0	0		0	0	0	0	0
7 Report Cash Position to Eastman & Plant Manager	0.1	5,886	1.5	0	0	0	0		0	0	0	0	0
8 Post Cash Info	0.1	3,924	1	0	0	0	0		0	0	0	0	0
9 Bank Recon	0.1	3,924	1	0	0	0	0		0	0	0	0	0
Activity Total	1.8	70,631	18	0	0	0	0						
		2,354	3.3%					3.3%	1,079	0	98	0	1,177

Activity **22-04**

Respond to Auditors

				Activity Note									
				Activity Driver Candidates			Facility						
	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Placate Internal Auditing	0.1	1,962	0.5	0	0	0	0	5	0	5	0	0	0
2 Placate DCAA	0.3	9,810	2.5	0	0	0	0		0	0	0	0	0
3 Deal w/ Consultants	0.1	3,924	1	0	0	0	0		0	0	0	0	0
4 Preparing Intnernal Procedures	0.1	5,886	1.5	0	0	0	0		0	0	0	0	0
Activity Total	0.6	21,582	5.5	0	0	0	0						
		98	0.5%					0.5%	0	98	0	0	0

Activity **22-05**

Prepare Reports

				Activity Note									
				Activity Driver Candidates			Facility						
	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Cost Statements	0.3	13,734	3.5	0	0	0	0	1	0	0	0	0	1
2 Appropriation Trial	0.2	7,848	2	0	0	0	0		0	0	0	0	0
3 Cost Reports	0.2	7,848	2	0	0	0	0		0	0	0	0	0
4 Financial Statements	0.1	5,886	1.5	0	0	0	0		0	0	0	0	0
5 Disclosure Statement	0.1	5,886	1.5	0	0	0	0		0	0	0	0	0
6 Third Party Reporting	0.1	3,924	1	0	0	0	0		0	0	0	0	0
7 Prepare Tax Returns	0.1	5,886	1.5	0	0	0	0	5	0	0	0	0	5
Activity Total	1.3	51,011	13	0	0	0	0						
		432	0.8%					0.8%	0	0	0	0	432

Activity **22-06**

Close Monthly

				Activity Note									
				Activity Driver Candidates			Facility						
	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Monthly Journal Entries	0.6	21,582	5.5	0	0	0	0		0	0	0	0	0

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
2 Journal Entry Control	0.1	3,924	1	0	0	0	0		0	0	0	0	0
3 Maintanence Records	0.1	3,924	1	0	0	0	0	10	0	0	0	0	10
4 Cost Distribution	0.1	3,924	1	0	0	0	0		0	0	0	0	0
5 Labor Distribution	0.1	5,886	1.5	0	0	0	0		0	0	0	0	0
6 Automotive Records	0.1	1,962	0.5	0	0	0	0		0	0	0	0	0
7 Production Records	0.3	11,772	3	0	0	0	0		0	0	0	0	0
8 Stores Records	0.0		0	0	0	0	0		0	0	0	0	0
9 Cost Redistribution	0.1	3,924	1	0	0	0	0		0	0	0	0	0
10 Price Gov't Furnished Material	0.0		0	0	0	0	0		0	0	0	0	0
11 Price Raw Material	0.0		0	0	0	0	0		0	0	0	0	0
12 Gov't Reimbursements	0.1	3,924	1	0	0	0	0		0	0	0	0	0
Activity Total	1.6	60,821	15.5	0	0	0	0						
		392	0.6%					0.6%	0	0	0	0	392

Activity **22-07**

Estimate Costs

Activity Note

	FTE	Cost	People Time	Activity Driver Candidates -	-	-	Facility -	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Contract Price Property (CCP)	0.5	19,620	5	0	0	0	0	3	3	0	0	0	0
2 Estimates for CAMS (Cost Accounts Managers S)	0.1	1,962	0.5	0	0	0	0	5	5	0	0	0	0
3 Code MOE (Memo of Expense)	0.1	1,962	0.5	0	0	0	0	5	0	0	0	0	5
4 BOM	0.1	1,962	0.5	0	0	0	0		0	0	0	0	0
5 Project Estimates	0.1	3,924	1	0	0	0	0	5	0	0	0	0	5
6 Labor Estimates	0.1	1,962	0.5	0	0	0	0		0	0	0	0	0
7 Employee Benefit Estimates	0.1	3,924	1	0	0	0	0		0	0	0	0	0
8 Cost Negotiations	0.1	3,924	1	0	0	0	0	5	0	0	0	0	5
9 Product Estimates	0.1	3,924	1	0	0	0	0		0	0	0	0	0
10 Out Year Cost Projections	0.1	3,924	1	0	0	0	0		0	0	0	0	0
Activity Total	1.2	47,087	12	0	0	0	0						
		1,177	2.5%					2.5%	687	0	0	0	490

Activity **22-08**

Develop Software

Activity Note

	FTE	Cost	People Time	Activity Driver Candidates -	-	-	Facility -	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Write Programs	0.3	9,810	2.5	0	0	0	0	1	0	0	0	0	1
2 Prepare Charts	0.1	1,962	0.5	0	0	0	0		0	0	0	0	0
3 Maintain Estimating Model	0.1	1,962	0.5	0	0	0	0		0	0	0	0	0

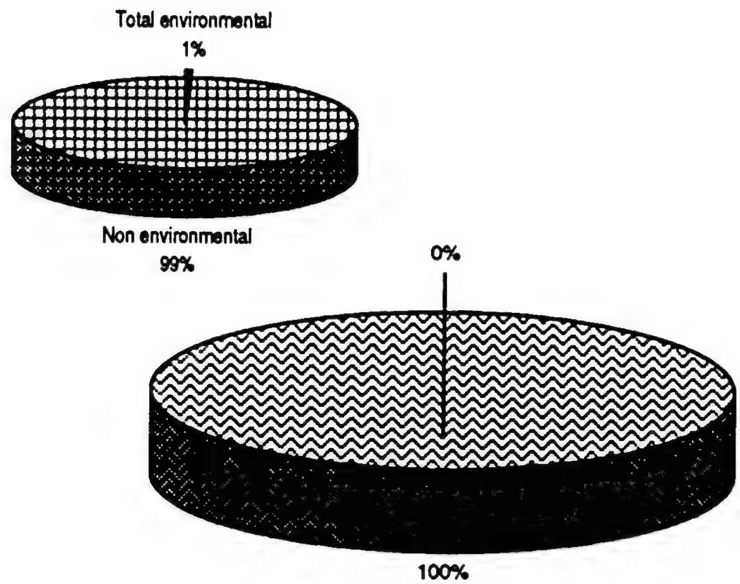
	FTE	Cost	People Time					Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
Activity Total	0.3	13,734	3.5	0	0	0	0						
		98	0.7%					0.7%	0	0	0	0	98

Activity **22-09**

Manage Teams

	FTE	Cost	People Time	Activity Note: Activity Driver Candidates -	-	-	Facility -	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Team Meetings	0.4	15,696	4	0	0	0	0		0	0	0	0	0
2 Training	0.1	3,924	1	0	0	0	0		0	0	0	0	0
3 Safety Meetings	0.3	11,772	3	0	0	0	0	8	8	0	0	0	0
4 Filing	0.1	1,962	0.5	0	0	0	0		0	0	0	0	0
5 IITPT (Inst Info Tech Plan Team)	0.1	1,962	0.5	0	0	0	0		0	0	0	0	0
6 Special Request	0.1	3,924	1	0	0	0	0		0	0	0	0	0
7 Personnel Matters	0.2	7,848	2	0	0	0	0		0	0	0	0	0
8 Litigation	0.1	1,962	0.5	0	0	0	0		0	0	0	0	0
Activity Total	1.3	49,049	12.5	0	0	0	0						
		942	1.9%					1.9%	942	0	0	0	0
Session Total	12.0	470,871	120	0	0	0	0						
		9,221	2.0%						6,435	98	98	0	2,590

Information Systems and Services



Preventing Detecting Correcting Disposing Reporting

Session Number 23
Group Information Systems and Services
Organization Support

Category	Cost	% of Total	% of Environmental
Preventing	-	0.0%	0.0%
Detecting	-	0.0%	0.0%
Correcting	-	0.0%	0.0%
Disposing	-	0.0%	0.0%
Reporting	3,823	0.5%	100.0%
Total environmental	3,823	0.5%	100.0%
Non environmental	691,243	99.5%	
Cost	695,066	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
23	Information Systems and Services								
23-01	Manage Inventory	0	0	0	0	0	0	60,818	0.0%
23-02	Operate System	0	0	0	0	2,896	2,896	115,844	2.5%
23-03	Support Applications	0	0	0	0	927	927	263,546	0.4%
23-04	Maintain Computing Environment	0	0	0	0	0	0	139,013	0.0%
23-05	Conduct Dept. Functions	0	0	0	0	0	0	28,961	0.0%
23-06	Develop Employee Skills	0	0	0	0	0	0	34,753	0.0%
23-07	Evaluate Heads	0	0	0	0	0	0	52,130	0.0%
Subtotal Information Systems and Services		0	0	0	0	3,823	3,823	695,066	0.5%

Holston Activity and Task Summary

Session 23 Information Systems and Services

Date	8/13/97	5 Participants	Philip Bailey, Gary Bridges, Vicki Goodsey, Judy Hillman, Janine Pleasant	Observers	Ennis, Glenn, Keith, Mark, Alan, Ross
Time	1:00	FTE:	12 79 Years Experience	Note	

Activity 23-01

Manage Inventory

Activity Note

Activity Driver Candidates Production Volume

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Maintain Computer Inventory	0.1	5,792	1	0	0	0	0		0	0	0	0	0
2 Surplus Junk Inventory	0.1	5,792	1	0	0	0	0		0	0	0	0	0
3 Order Replacement Parts	0.2	11,584	2	0	0	0	0		0	0	0	0	0
4 Paper Inventory	0.2	11,584	2	0	0	0	0		0	0	0	0	0
5 Salvage Computer Parts from Excess Computers	0.3	14,481	2.5	0	0	0	0		0	0	0	0	0
6 Tape Cartridge Inventory	0.2	11,584	2	0	0	0	0		0	0	0	0	0
Activity Total	1.1	60,818	10.5	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity 23-02

Operate System

Activity Note

Activity Driver Candidates Facility

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Execute Batch Runs	0.2	11,584	2	0	0	0	0		0	0	0	0	0
2 Monitor Mainframe and Network	0.9	52,130	9	0	0	0	0		0	0	0	0	0
3 Backup System	0.2	11,584	2	0	0	0	0		0	0	0	0	0
4 Distribute Print-outs	0.2	11,584	2	0	0	0	0		0	0	0	0	0
5 Payroll Printing Deposits Slips	0.2	11,584	2	0	0	0	0		0	0	0	0	0
6 Check Cooling System	0.3	14,481	2.5	0	0	0	0		0	0	0	0	0
7 Environmental Hazards Reporting	0.1	2,896	0.5	0	0	0	0	100	0	0	0	0	100
Activity Total	2.0	115,844	20	0	0	0	0						
		2,896	2.5%					2.5%	0	0	0	0	2,896

Activity 23-03

Support Applications

Activity Note

Activity Driver Candidates Facility

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Design and Develop Computer Applications	1.6	92,675	16	0	0	0	0	1	0	0	0	0	1
2 Program Troubleshoot for Users	1.5	86,883	15	0	0	0	0		0	0	0	0	0
3 Documnetation Program/System	0.7	40,546	7	0	0	0	0		0	0	0	0	0
4 Check Previous Night and Batch Runs	0.8	43,442	7.5	0	0	0	0		0	0	0	0	0

	FTE	Cost	People Time	-	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
Activity Total	4.5	263,546	45.5	0	0	0	0						
		927	0.4%					0.4%	0	0	0	0	927

Activity **23-04**

Maintain Computing Environment

Activity Note

Activity Driver Candidates / Production Volume

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Check Status of Computer Systems	0.1	8,688	1.5	0	0	0	0		0	0	0	0	0
2 Morning Reports	0.1	5,792	1	0	0	0	0		0	0	0	0	0
3 Write Work Orders	0.0		0	0	0	0	0		0	0	0	0	0
4 Prepare Requisitions for Hardware & Software	0.3	14,481	2.5	0	0	0	0		0	0	0	0	0
5 Fix Computers Already in Shop	0.3	14,481	2.5	0	0	0	0		0	0	0	0	0
6 Setup New Computers (PC's)	0.3	14,481	2.5	0	0	0	0		0	0	0	0	0
7 Install New Software	0.3	14,481	2.5	0	0	0	0		0	0	0	0	0
8 On Call	0.1	8,688	1.5	0	0	0	0		0	0	0	0	0
9 Run Cable Network	0.1	2,896	0.5	0	0	0	0		0	0	0	0	0
10 Unlock Shop	0.0		0	0	0	0	0		0	0	0	0	0
11 Install Hardware	0.2	11,584	2	0	0	0	0		0	0	0	0	0
12 Help Desk	0.5	26,065	4.5	0	0	0	0		0	0	0	0	0
13 Surf Internet for Resolutions	0.1	2,896	0.5	0	0	0	0		0	0	0	0	0
14 Provide Computer Manuals to Customers	0.1	2,896	0.5	0	0	0	0		0	0	0	0	0
15 Contact Outside Vendors for Help	0.1	5,792	1	0	0	0	0		0	0	0	0	0
16 Recover Files from Backup	0.0		0	0	0	0	0		0	0	0	0	0
17 Evaluate Hardware & Software	0.1	5,792	1	0	0	0	0		0	0	0	0	0
18 Supply Computer Paper to Customers	0.0		0	0	0	0	0		0	0	0	0	0
Activity Total	2.4	139,013	24	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **23-05**

Conduct Dept. Functions

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Attend Safety Meetings	0.3	14,481	2.5	0	0	0	0		0	0	0	0	0
2 Coordinate Safety Meetings	0.1	2,896	0.5	0	0	0	0		0	0	0	0	0
3 Attend Dept. Team Meetings	0.2	11,584	2	0	0	0	0		0	0	0	0	0
4 Actions Communication Officer Letters	0.0		0	0	0	0	0		0	0	0	0	0

	FTE	Cost	People Time	-	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
Activity Total	0.5	28,961	5	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **23-06**

Develop Employee Skills

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Reading	0.5	26,065	4.5	0	0	0	0		0	0	0	0	0
2 Training	0.1	8,688	1.5	0	0	0	0		0	0	0	0	0
Activity Total	0.6	34,753	6	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **23-07**

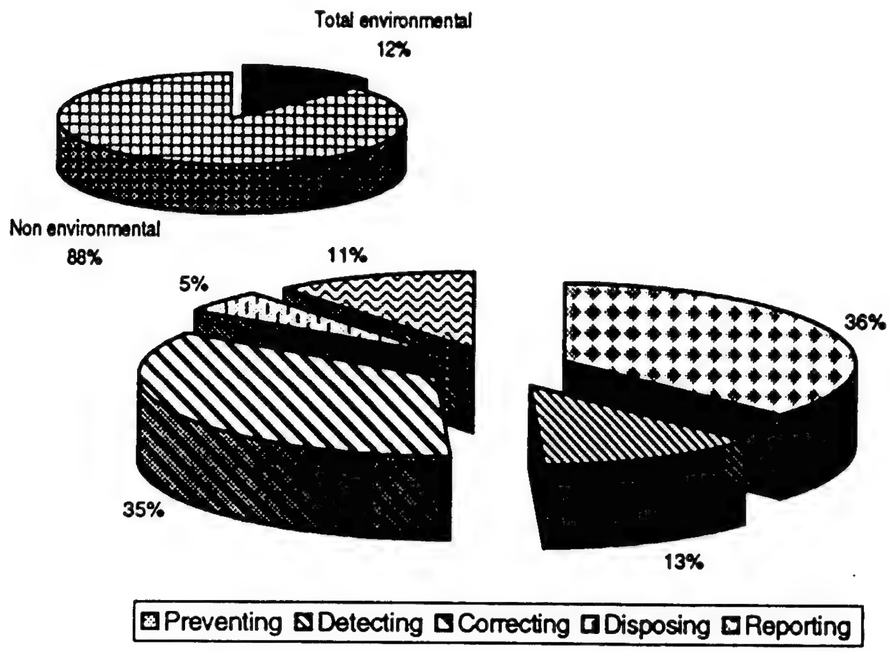
Evaluate Heads

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Future Planning	0.5	28,961	5	0	0	0	0		0	0	0	0	0
2 414, 415 Budgets	0.4	23,169	4	0	0	0	0		0	0	0	0	0
Activity Total	0.9	52,130	9	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0
Session Total	12.0	695,066	120	0	0	0	0						
		3,823	0.6%						0	0	0	0	3,823

Engineering and Project Management



Session Number	24
Group	Engineering and Project Management
Organization	Maintenance

Category	Cost	% of Total	% of Environmental
Preventing	40,007	4.5%	36.6%
Detecting	13,868	1.6%	12.7%
Correcting	38,136	4.3%	34.9%
Disposing	5,173	0.6%	4.7%
Reporting	12,217	1.4%	11.2%
Total environmental	109,400	12.4%	100.0%
Non environmental	771,083	87.6%	
Cost	880,483	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
<u>24</u>	<u>Engineering and Project Management</u>								
24-01	Support Operations	10,456	0	7,924	1,101	1,761	21,242	193,706	11.0%
24-02	Design Projects	24,874	13,868	13,868	3,632	0	56,241	345,589	16.3%
24-03	Manage Projects	3,797	0	16,344	440	10,456	31,037	184,901	16.8%
24-04	Manage Dept.	880	0	0	0	0	880	156,286	0.6%
Subtotal Engineering and Project Managemen		40,007	13,868	38,136	5,173	12,217	109,400	880,483	12.4%

Holston Activity and Task Summary

Session 24 Engineering and Project Management

Date 8/14/97 5 Participants Bill Lewis, Allen Cross, Charlie Fowler, Bill Miller, Andy Polahar Observers Ennis, Glenn, Keith, Mark, Alan, Ross

Time 8:00 FTE: 20 128 Years Experience Note

Activity **24-01**

Support Operations

Activity Note

Activity Driver Candidates Acid (10%), Other Explosives (40%), Utilities (30%), Infrastructure(20%)

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Design Solution to Operational Problem	0.6	26,414	6	0	0	0	0	30	0	0	30	0	0
2 Support Operation & Closure of Landfill	0.1	2,201	0.5	0	0	0	0	100	50	0	0	50	0
3 Support Maintanence	0.2	8,805	2	0	0	0	0	10	10	0	0	0	0
8 Store & Maintain Plant Drawings & Equipment Data	0.4	17,610	4	0	0	0	0		0	0	0	0	0
9 PC/EC Review	0.5	19,811	4.5	0	0	0	0		0	0	0	0	0
10 Bridge Inspection/Repair	0.1	4,402	1	0	0	0	0	10	10	0	0	0	0
11 Building Structural Inspection	0.1	2,201	0.5	0	0	0	0		0	0	0	0	0
12 Real Estate Management	0.1	2,201	0.5	0	0	0	0	5	5	0	0	0	0
13 Land Survey	0.0		0	0	0	0	0		0	0	0	0	0
15 As Build Drawing	0.4	17,610	4	0	0	0	0	10	0	0	0	0	10
16 Prepare and Update Standards	0.4	17,610	4	0	0	0	0		0	0	0	0	0
17 Find/Locate Drawings for Plant Personnel	0.0		0	0	0	0	0		0	0	0	0	0
18 PECI Meetings Support	0.1	4,402	1	0	0	0	0		0	0	0	0	0
19 ASME Pressure Specialist	0.2	8,805	2	0	0	0	0		0	0	0	0	0
20 HDC Energy Coordinator	0.6	26,414	6	0	0	0	0		0	0	0	0	0
21 Energy Studies	0.1	4,402	1	0	0	0	0		0	0	0	0	0
22 Spill Plan Drawings	0.0		0	0	0	0	0		0	0	0	0	0
23 Process Safety Management	0.2	8,805	2	0	0	0	0	30	30	0	0	0	0
24 Process Hazard Analysis	0.4	17,610	4	0	0	0	0	30	30	0	0	0	0
26 Run Blueprints	0.1	4,402	1	0	0	0	0		0	0	0	0	0
Activity Total	4.4	193,706	44	0	0	0	0						
		21,242	11.0%					11.0%	10,456	0	7,924	1,101	1,761

Activity **24-02**

Design Projects

Activity Note

Activity Driver Candidates CLIN (40%), Acid (10%), Other Explosives Manufacturing (25%), Utilities (25%)

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Prepare Subcontractor Specs	1.1	48,427	11	0	0	0	0	15	7.5	0	0	7.5	0
2 Consult w/ Team Members on Design and Problems	0.4	17,610	4	0	0	0	0	5	5	0	0	0	0

3 Design Electrical Power, Lighting, Etc	0.6	26,414	6	0	0	0	0	10	10	0	0	0	0
4 Design Process Control Systems	0.3	13,207	3	0	0	0	0	10	10	0	0	0	0
6 Equipment & Materials Specs	0.9	41,823	9.5	0	0	0	0		0	0	0	0	0
7 Evaluate Bids	0.0		0	0	0	0	0		0	0	0	0	0
8 Inspect Equipment	0.1	4,402	1	0	0	0	0		0	0	0	0	0
9 Program Process Control Computers	0.8	35,219	8	0	0	0	0	10	10	0	0	0	0
10 Support CE Construction	0.1	6,604	1.5	0	0	0	0	90	0	45	45	0	0
11 Review Job Site	0.0		0	0	0	0	0		0	0	0	0	0
12 Site Planning	0.1	2,201	0.5	0	0	0	0	40	40	0	0	0	0
13 Design Calculating	0.3	11,006	2.5	0	0	0	0	15	15	0	0	0	0
15 Prepare Engineering Drawings	1.9	81,445	18.5	0	0	0	0	10	10	0	0	0	0
16 Prepare PDE for CE Design	0.3	13,207	3	0	0	0	0	90	0	45	45	0	0
17 Review CE Design	0.3	11,006	2.5	0	0	0	0	90	0	45	45	0	0
18 Support Facility Construction	0.2	8,805	2	0	0	0	0		0	0	0	0	0
19 A/E Coordination	0.1	2,201	0.5	0	0	0	0		0	0	0	0	0
20 Environmental Assesment	0.1	2,201	0.5	0	0	0	0	100	100	0	0	0	0
21 Solve Construction Problems	0.5	19,811	4.5	0	0	0	0		0	0	0	0	0
Activity Total	7.8	345,589	78.5	0	0	0	0						
		56,241	16.3%					16.3%	24,874	13,868	13,868	3,632	0

Activity **24-03**

Manage Projects

Activity Note

Activity Driver Candidates CLIN(75%), Acids(3%), Other Explosives(10%), Utilities(12%)

	FTE	Cost	People Time	-	-	-	-	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Project Scheduling	0.1	6,604	1.5	0	0	0	0		0	0	0	0	0
2 Program Maintanence Inactive Facility	0.1	4,402	1	0	0	0	0	10	0	0	0	10	0
3 Government Letters	0.5	22,012	5	0	0	0	0	15	0	0	0	0	15
4 Status Work Performance and Cost	0.3	13,207	3	0	0	0	0		0	0	0	0	0
5 Deal w/ Auditors	0.1	6,604	1.5	0	0	0	0		0	0	0	0	0
6 Maintain & Status Cost Schedule Control System	0.1	6,604	1.5	0	0	0	0		0	0	0	0	0
7 Project Review Meetings	0.7	28,616	6.5	0	0	0	0	25	0	0	0	0	25
8 Project Proposals	0.3	13,207	3	0	0	0	0	50	0	0	50	0	0
9 Project Priority Meetings	0.3	13,207	3	0	0	0	0	10	0	0	10	0	0
10 Cost Account Management	0.1	2,201	0.5	0	0	0	0		0	0	0	0	0
11 Develop Project Budgets for Future Year	0.3	15,408	3.5	0	0	0	0	30	0	0	30	0	0
12 Write Work Orders	0.1	2,201	0.5	0	0	0	0		0	0	0	0	0
13 Write MOE's	0.0		0	0	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session 24 Engineering and Project Management

14 Prepare Cost Estimates	1.1	50,628	11.5	0	0	0	0	15	7.5	0	7.5	0	0
Activity Total	4.2	184,901	42	0	0	0	0						
		31,037	16.8%					16.8%	3,797	0	16,344	440	10,456

Activity **24-04**

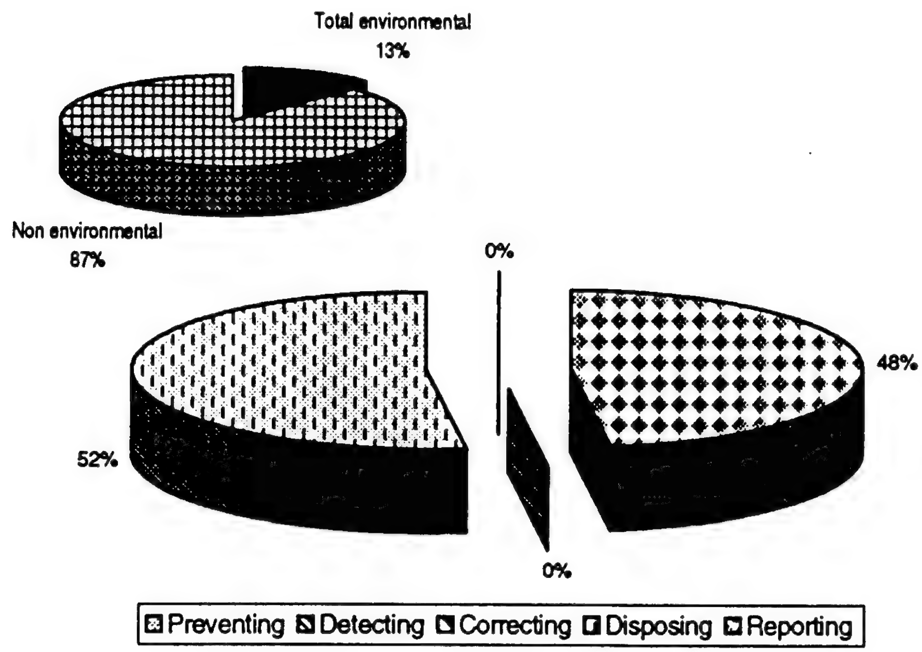
Manage Dept.

Activity Note

Activity Driver Candidates

	FTE	Cost	People Time	-	-	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Review To-Do List	0.0		0	0	0	0	0		0	0	0	0	0
2 Meeting Request	0.1	4,402	1	0	0	0	0		0	0	0	0	0
3 ID Issues/Concerns	0.0		0	0	0	0	0		0	0	0	0	0
4 Safety Meeting & Training	0.0		0	0	0	0	0		0	0	0	0	0
5 QM Meetings	0.2	8,805	2	0	0	0	0		0	0	0	0	0
6 Training to Maintain Technical Edge	0.2	8,805	2	0	0	0	0	10	10	0	0	0	0
7 CK Staffing	0.0		0	0	0	0	0		0	0	0	0	0
8 Maintain Engineer Network	0.8	35,219	8	0	0	0	0		0	0	0	0	0
9 Respond to Calls-Email Status-Money	0.0		0	0	0	0	0		0	0	0	0	0
10 Provide Secretarial Support	0.9	41,823	9.5	0	0	0	0		0	0	0	0	0
11 Learns New Software & Electronis Systems	1.1	48,427	11	0	0	0	0		0	0	0	0	0
12 Assign Work Tasks	0.2	8,805	2	0	0	0	0		0	0	0	0	0
Activity Total	3.6	156,286	35.5	0	0	0	0						
		880	0.6%					0.6%	880	0	0	0	0
Session Total	20.0	880,483	200	0	0	0	0						
		109,400	12.4%						40,007	13,868	38,136	5,173	12,217

Medical



Session Number	I-1
Group	Medical
Organization	Support

Category	Cost	% of Total	% of Environmental
Preventing	6,540	6.0%	47.7%
Detecting	-	0.0%	0.0%
Correcting	-	0.0%	0.0%
Disposing	7,160	6.6%	52.3%
Reporting	-	0.0%	0.0%
Total environmental	13,700	12.6%	100.0%
Non environmental	94,830	87.4%	
Cost	108,531	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
I-1	Medical								
I-1-01	Physician Clinical Duties	110	0	0	0	0	110	1,103	10.0%
I-1-02	Nursing Clinical Duties	260	0	0	1,562	0	1,823	26,037	7.0%
I-1-03	Clinical Duties	1,464	0	0	814	0	2,278	33,010	6.9%
I-1-04	Meetings	0	0	0	0	0	0	441	0.0%
I-1-05	Technician Administrative Duties	0	0	0	78	0	78	10,415	0.8%
I-1-06	Testing	2,617	0	0	2,617	0	5,234	15,596	33.6%
I-1-07	Voluntary Exams	1,412	0	0	1,412	0	2,824	5,649	50.0%
I-1-08	Required Examinations	513	0	0	513	0	1,027	5,424	18.9%
I-1-09	Testings for Drugs/Alcohol	163	0	0	163	0	326	10,856	3.0%
Subtotal Medical		6,540	0	0	7,160	0	13,700	108,531	12.6%

Holston Activity and Task Summary

Session I-1 Medical

Date 8/13/97 | 1 Participants | P Davis | Observers Alan

Time 1:00 | FTE: | 3 15 Years Experience | Note

Activity **I-1-01**

Physician Clinical Duties

Activity Note

Activity Driver Candidates

	FTE	Cost	Physician Time	Nurse Time	Technician Time	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Review Lab Work	0.1	221	0.5	0	0	0	0		0	0	0	0	0
2 Annual Training	0.1	221	0.5	0	0	0	0	50	50	0	0	0	0
3 Refer to Outside Facilities	0.1	221	0.5	0	0	0	0		0	0	0	0	0
4 Grant Medical Clearance to Employee Transfers	0.1	221	0.5	0	0	0	0		0	0	0	0	0
5 Work Restricition Assignments to Employees	0.1	221	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.7	1,103	2.5	0	0	0	0						
		110	10.0%					10.0%	110	0	0	0	0

Activity **I-1-02**

Nursing Clinical Duties

Activity Note

Activity Driver Candidates

	FTE	Cost	Physician Time	Nurse Time	Technician Time	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Give Injections	0.0	5,207	0	1	0	0	0	35	5	0	0	30	0
2 Blood Pressure Checks	0.0	5,207	0	1	0	0	0		0	0	0	0	0
3 Physical Therapy	0.0	10,415	0	2	0	0	0		0	0	0	0	0
4 Visiting Nurse Records/Telephone	0.0	2,604	0	0.5	0	0	0		0	0	0	0	0
5 Pre Disability Interviews	0.0	2,604	0	0.5	0	0	0		0	0	0	0	0
Activity Total	0.0	26,037	0	5	0	0	0						
		1,823		7.0%				7.0%	260	0	0	1,562	0

Activity **I-1-03**

Clinical Duties

Activity Note

Activity Driver Candidates

	FTE	Cost	Physician Time	Nurse Time	Technician Time	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Return to Work Exam of Sick/Injured Employees	0.1	5,428	0.5	1	0	0	0		0	0	0	0	0
2 Physical Exams (Hands On)	0.1	221	0.5	0	0	0	0	5	5	0	0	0	0
3 Exam, Diagnose, Treat Job Illness/Injury	0.1	5,428	0.5	1	0	0	0	5	5	0	0	0	0
4 Exam, Diagnose, Treat Non Job Related Illness/Injury	0.3	5,649	1	1	0	0	0	5	5	0	0	0	0
5 Follow-up Consultations for Ill/Injured Employees	0.1	2,824	0.5	0.5	0	0	0		0	0	0	0	0

Holston Activity and Task Summary

Session I-1 Medical

Task	FTE	Cost	Physician Time	Nurse Time	Technician Time	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
6 Treatment of Eye Injuries	0.1	2,824	0.5	0.5	0	0	0	3	3	0	0	0	0
7 Counseling	0.0	5,207	0	1	0	0	0		0	0	0	0	0
8 Medical Emergency Treatment	0.1	5,428	0.5	1	0	0	0	30	15	0	0	15	0
Activity Total	1.2	33,010	4	6	0	0	0						
		2,278	6.6%	6.9%				6.9%	1,464	0	0	814	0

Activity **I-1-04**

Meetings

Activity Note

Activity Driver Candidates

Task	*FTE*	Cost	Physician Time	Nurse Time	Technician Time	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Visiting Nurse Meetings	0.0		0	0	0	0	0		0	0	0	0	0
2 Attendence of Medical Review Meetings	0.1	221	0.5	0	0	0	0		0	0	0	0	0
3 Disciplinary Review Meeting	0.0		0	0	0	0	0		0	0	0	0	0
4 Worker's Compensation Meeting	0.1	221	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.3	441	1	0	0	0	0						
		0	0.0%					0.0%	0	0	0	0	0

Activity **I-1-05**

Technician Administrative Duties

Activity Note

Activity Driver Candidates

Task	*FTE*	Cost	Physician Time	Nurse Time	Technician Time	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Maintain OSHA Log	0.0	2,604	0	0.5	0	0	0		0	0	0	0	0
2 Order, Inventory, & Dispose of Drugs & Supplies (Monthly)	0.0	2,604	0	0.5	0	0	0	3	0	0	0	3	0
3 Administer Blood Bank	0.0	5,207	0	1	0	0	0		0	0	0	0	0
Activity Total	0.0	10,415	0	2	0	0	0						
		78		0.7%				0.8%	0	0	0	78	0

Activity **I-1-06**

Testing

Activity Note

Activity Driver Candidates

Task	*FTE*	Cost	Physician Time	Nurse Time	Technician Time	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 EKG	0.0	729	0	0.14	0	0	0		0	0	0	0	0
2 Audiograms	0.0	911	0	0.175	0	0	0		0	0	0	0	0
3 Phlebotomy	0.0	10,206	0	1.96	0	0	0	50	25	0	0	25	0
4 X-Rays	0.0	1,354	0	0.26	0	0	0		0	0	0	0	0
5 Pnulmony Function	0.0	573	0	0.11	0	0	0	2	1	0	0	1	0
6 Vision Testing	0.0	625	0	0.12	0	0	0		0	0	0	0	0
7 Urine Testing	0.0	1,198	0	0.23	0	0	0	10	5	0	0	5	0

	FTE	Cost	Physician Time	Nurse Time	Technician Time	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
Activity Total	0.0	15,596	0	2.995	0	0	0						
		5,234		33.6%				33.6%	2,617	0	0	2,617	0

Activity I-1-07

Voluntary Exams

Activity Note

Activity Driver Candidates

	FTE	Cost	Physician Time	Nurse Time	Technician Time	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Multi-Phasic Exams	0.3	441	1	0	0	0	0	50	25	0	0	25	0
2 Met-Life Exams	0.0		0	0	0	0	0	50	25	0	0	25	0
3 Wellness Exams	0.0	5,207	0	1	0	0	0	50	25	0	0	25	0
Activity Total	0.3	5,649	1	1	0	0	0						
		2,824	50.0%	50.0%				50.0%	1,412	0	0	1,412	0

Activity I-1-08

Required Examinations

Activity Note

Activity Driver Candidates

	FTE	Cost	Physician Time	Nurse Time	Technician Time	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Asbestos Exams	0.0	602	0.055	0.111	0	0	0		0	0	0	0	0
2 Formaldehyde Exams	0.0	239	0.022	0.044	0	0	0		0	0	0	0	0
3 Lead Exams	0.0	1,449	0.133	0.267	0	0	0	50	25	0	0	25	0
4 Pesticide Exams	0.0	604	0.06	0.111	0	0	0	50	25	0	0	25	0
5 DOT/ICC Exams	0.1	2,410	0.222	0.444	0	0	0		0	0	0	0	0
6 PreEmployment Exams	0.0	119	0.011	0.022	0	0	0		0	0	0	0	0
Activity Total	0.2	5,424	0.503	0.999	0	0	0						
		1,027	19.2%	18.9%				18.9%	513	0	0	513	0

Activity I-1-09

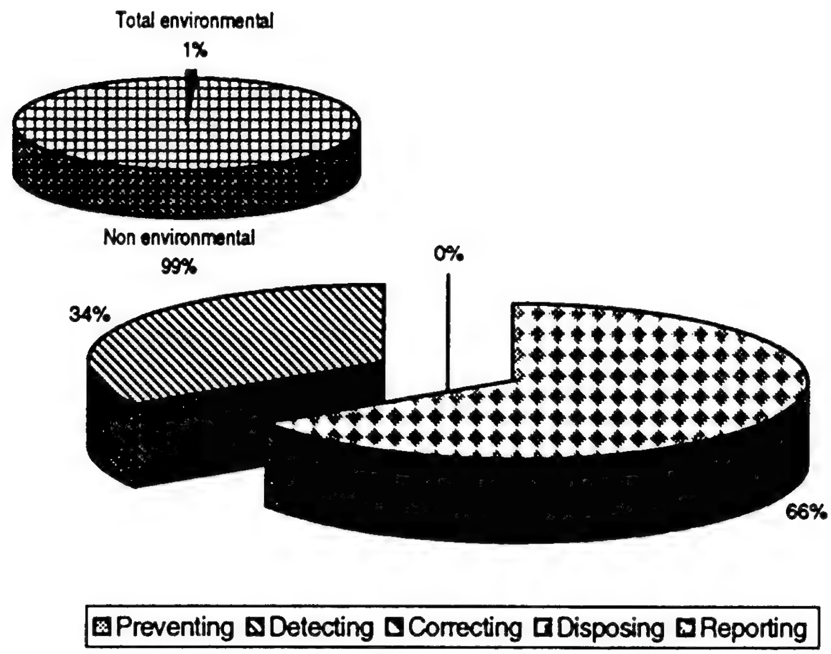
Testings for Drugs/Alcohol

Activity Note

Activity Driver Candidates

	FTE	Cost	Physician Time	Nurse Time	Technician Time	-	-	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Drug Screeing & Testing	0.1	5,428	0.5	1	0	0	0	3	1.5	0	0	1.5	0
2 Alchohol	0.1	5,428	0.5	1	0	0	0	3	1.5	0	0	1.5	0
3 Medical Review Officer Duties	0.0		0	0	0	0	0		0	0	0	0	0
Activity Total	0.3	10,856	1	2	0	0	0						
		326	3.0%	3.0%				3.0%	163	0	0	163	0
Session Total	3.0	108,531	10.00	19.99	0	0	0						
		13,700	11.4%	12.7%					6,540	0	0	7,160	0

Contracting Services



Session Number	I-2
Group	Contracting Services
Organization	Support

Category	Cost	% of Total	% of Environmental
Preventing	3,053	0.5%	65.8%
Detecting	1,587	0.2%	34.2%
Correcting	-	0.0%	0.0%
Disposing	-	0.0%	0.0%
Reporting	-	0.0%	0.0%
Total environmental	4,639	0.7%	100.0%
Non environmental	641,857	99.3%	
Cost	646,497	100.0%	

Holston Environmental Activity Summary

		Preventing	Detecting	Correcting	Disposing	Reporting	Total Green	Total Activity	Green %
I-2	Contracting Services								
I-2-01	Administer Contracts	628	198	0	0	0	826	52,891	1.6%
I-2-02	Setup Contract	331	66	0	0	0	397	19,834	2.0%
I-2-03	Administer Standing Contracts	0	1,322	0	0	0	1,322	52,891	2.5%
I-2-04	Janitorial	820	0	0	0	0	820	273,293	0.3%
I-2-05	Laundry	1,080	0	0	0	0	1,080	54,023	2.0%
I-2-06	Operate Railroad	194	0	0	0	0	194	193,565	0.1%
I-2-07	Mow Grass	0	0	0	0	0	0	0	
Subtotal Contracting Services		3,053	1,587	0	0	0	4,639	646,497	0.7%

Holston Activity and Task Summary

Session I-2 Contracting Services

Date 8/12/97 1 Participants John Shelby Observers Alan

Time 8:00 FTE: 2 22 Years Experience Note

Activity **I-2-01**

Activity Note

Administer Contracts

Activity Driver Candidates Contract Award

	FTE	Cost	People Time	Janitorial	Laundry	Grass Mowing	RailRoad	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Handle Progress Payments	0.1	6,611	1	0	0	0	0		0	0	0	0	0
2 Coordinate Safety & Environment Permits	0.1	3,306	0.5	0	0	0	0	1	1	0	0	0	0
3 Sign Clearance Slips	0.1	3,306	0.5	0	0	0	0	1	1	0	0	0	0
4 Coordinate Job Changes	0.1	6,611	1	0	0	0	0	1	1	0	0	0	0
5 Assure Contract Compliance	0.2	9,917	1.5	0	0	0	0	5	5	0	0	0	0
6 Daily Safety Checks	0.1	3,306	0.5	0	0	0	0		0	0	0	0	0
7 Daily Progress Review	0.2	9,917	1.5	0	0	0	0	2	0	2	0	0	0
8 Coordinate Outages	0.1	3,306	0.5	0	0	0	0		0	0	0	0	0
9 Create Punch List	0.1	3,306	0.5	0	0	0	0		0	0	0	0	0
10 F/U Punch List	0.1	3,306	0.5	0	0	0	0		0	0	0	0	0
Activity Total	0.8	52,891	8	0	0	0	0						
		826	1.6%					1.6%	628	198	0	0	0

Activity **I-2-02**

Activity Note 1 blue on Overall Activity

Setup Contract

Activity Driver Candidates Contracts

	FTE	Cost	People Time	Janitorial	Laundry	Grass Mowing	RailRoad	Environ mental	Prevent ing	Detect ing	Correct ing	Dispos ing	Report ing
1 Schedule Security, Environmental, and Safety Training	0.0		0	0	0	0	0	10	10	0	0	0	0
2 Write Work Orders	0.1	6,611	1	0	0	0	0		0	0	0	0	0
3 Initiate Job Closing Notice	0.0		0	0	0	0	0	1	0	1	0	0	0
4 Familiarize w/ Design & Job Site	0.1	6,611	1	0	0	0	0	5	5	0	0	0	0
5 Attend Job Showing w/ Potential Contractors	0.0		0	0	0	0	0		0	0	0	0	0
6 Award Meeting	0.0		0	0	0	0	0		0	0	0	0	0
7 Final Job Inspection	0.1	6,611	1	0	0	0	0	1	0	1	0	0	0
8 OSHA Requirments Check	0.0		0	0	0	0	0		0	0	0	0	0
9 Coordinate Contractor Facility Placement	0.0		0	0	0	0	0		0	0	0	0	0
10 Final Job Schedule	0.0		0	0	0	0	0		0	0	0	0	0
Activity Total	0.3	19,834	3	0	0	0	0						
		397	2.0%					2.0%	331	66	0	0	0

Holston Activity and Task Summary

Session I-2 Contracting Services

Activity I-2-03
Administer Standing Contracts

Activity Note

Activity Driver Candidates

Task	*FTE*	Cost	People Time	Janitorial	Laundry	Grass Mowing	RailRoad	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Review and Approve Invoices	0.3	19,834	3	0	0	0	0		0	0	0	0	0
2 Daily Inspections	0.4	26,445	4	0	0	0	0	5	0	5	0	0	0
3 Handle Complaints	0.1	6,611	1	0	0	0	0		0	0	0	0	0
Activity Total	0.8	52,891	8	0	0	0	0						
		1,322	2.5%					2.5%	0	1,322	0	0	0

Activity I-2-04
Janitorial

Activity Note

Activity Driver Candidates Space

Task	*FTE*	Cost	People Time	Janitorial	Laundry	Grass Mowing	RailRoad	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Clean Refrigirators	0.0	27,329	0	1	0	0	0		0	0	0	0	0
2 Clean Building	0.0	81,988	0	3	0	0	0	1	0.5	0	0	0	0
3 Dump Trash	0.0	27,329	0	1	0	0	0		0	0	0	0	0
4 Clean Windows	0.0	27,329	0	1	0	0	0		0	0	0	0	0
5 Clean Showers and Baths	0.0	81,988	0	3	0	0	0	1	0.5	0	0	0	0
6 Restock Soap & Towels	0.0	27,329	0	1	0	0	0		0	0	0	0	0
Activity Total	0.0	273,293	0	10	0	0	0						
		820		0.3%				0.3%	820	0	0	0	0

Activity I-2-05
Laundry

Activity Note

Activity Driver Candidates Production & Maintanence People

Task	*FTE*	Cost	People Time	Janitorial	Laundry	Grass Mowing	RailRoad	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Pick up & Return Soiled Laundry at Change House	0.0	21,609	0	0	4	0	0		0	0	0	0	0
2 Wash & Dry	0.0	21,609	0	0	4	0	0	5	5	0	0	0	0
3 Repair Torn Clothing	0.0	10,805	0	0	2	0	0		0	0	0	0	0
Activity Total	0.0	54,023	0	0	10	0	0						
		1,080			2.0%			2.0%	1,080	0	0	0	0

Activity I-2-06
Operate Railroad

Activity Note

Activity Driver Candidates Production Coal Acid

Task	*FTE*	Cost	People Time	Janitorial	Laundry	Grass Mowing	RailRoad	Environ mental	Prevent Ing	Detect Ing	Correct Ing	Dispos Ing	Report Ing
1 Inspect Track	0.0	38,713	0	0	0	0	2		0	0	0	0	0
2 Pland & Coordinate Repair	0.0	19,357	0	0	0	0	1		0	0	0	0	0

Holston Activity and Task Summary

Session I-2 Contracting Services

	FTE	Cost	People Time	Janitorial	Laundry	Grass Mowing	RailRoad	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
3 Pull and Place Cars	0.0	58,070	0	0	0	0	3		0	0	0	0	0
4 Maintain Track	0.0	58,070	0	0	0	0	3		0	0	0	0	0
5 Maintain Engines	0.0	19,357	0	0	0	0	1	1	1	0	0	0	0
Activity Total	0.0	193,565	0	0	0	0	10						
		194					0.1%	0.1%	194	0	0	0	0

Activity I-2-07

Mow Grass

Activity Note

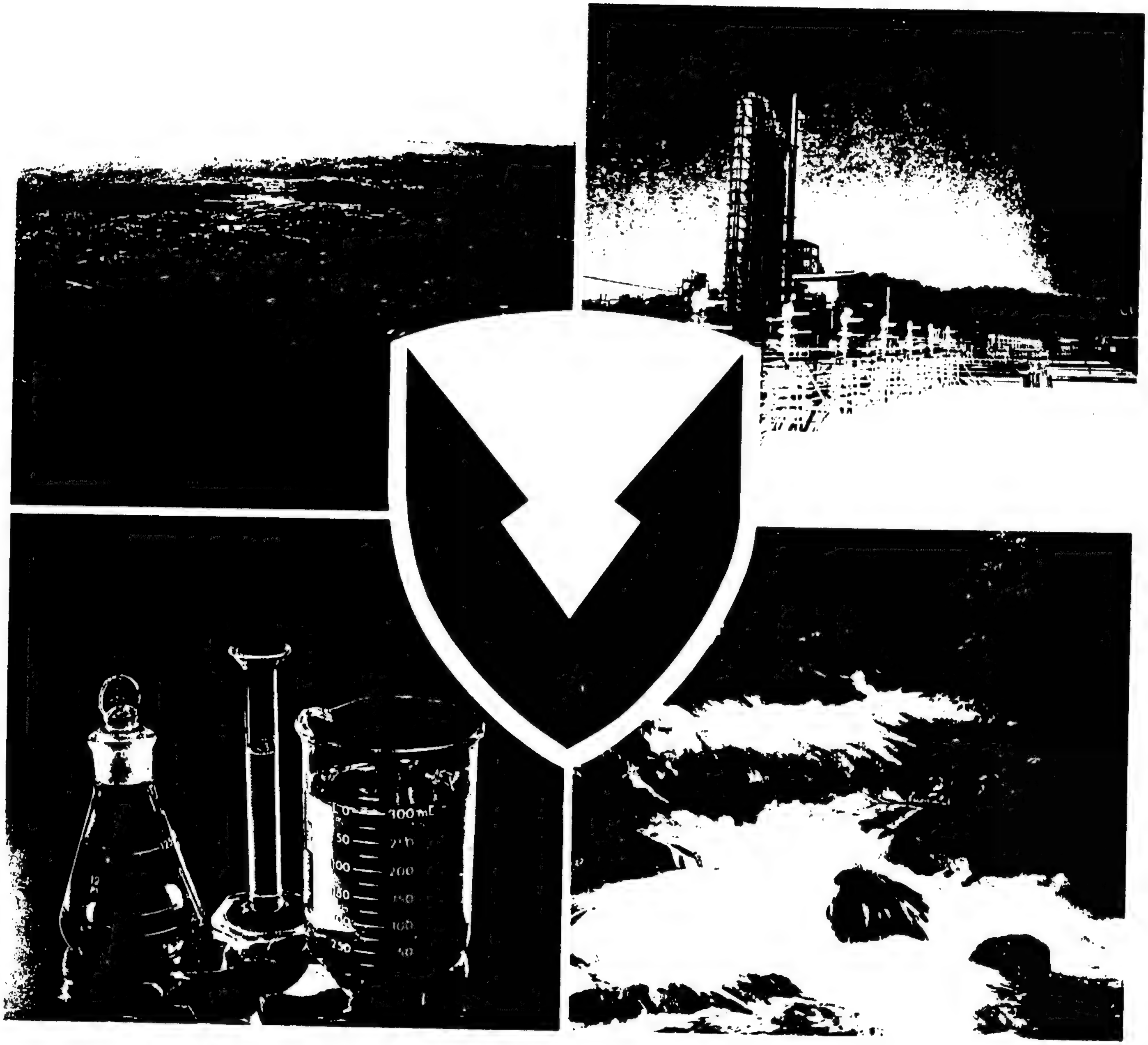
Activity Driver Candidates

	FTE	Cost	People Time	Janitorial	Laundry	Grass Mowing	RailRoad	Environmental	Preventing	Detecting	Correcting	Disposing	Reporting
1 Grass Mowing	0.0	0	0	0	0	10	0	1	0	0	1	0	0
Activity Total	0.0	0	0	0	0	10	0						
		0				1.0%		#Num!	0	0	0	0	0
Session Total	2.0	646,497	19	10	10	10	10						
		4,639	2.0%	0.3%	2.0%	1.0%	0.1%		3,053	1,587	0	0	0

Holston
Environmental Activity Cost Analysis
Appendix D
Holston Army Ammunition Plant and
Holston Defense Corporation

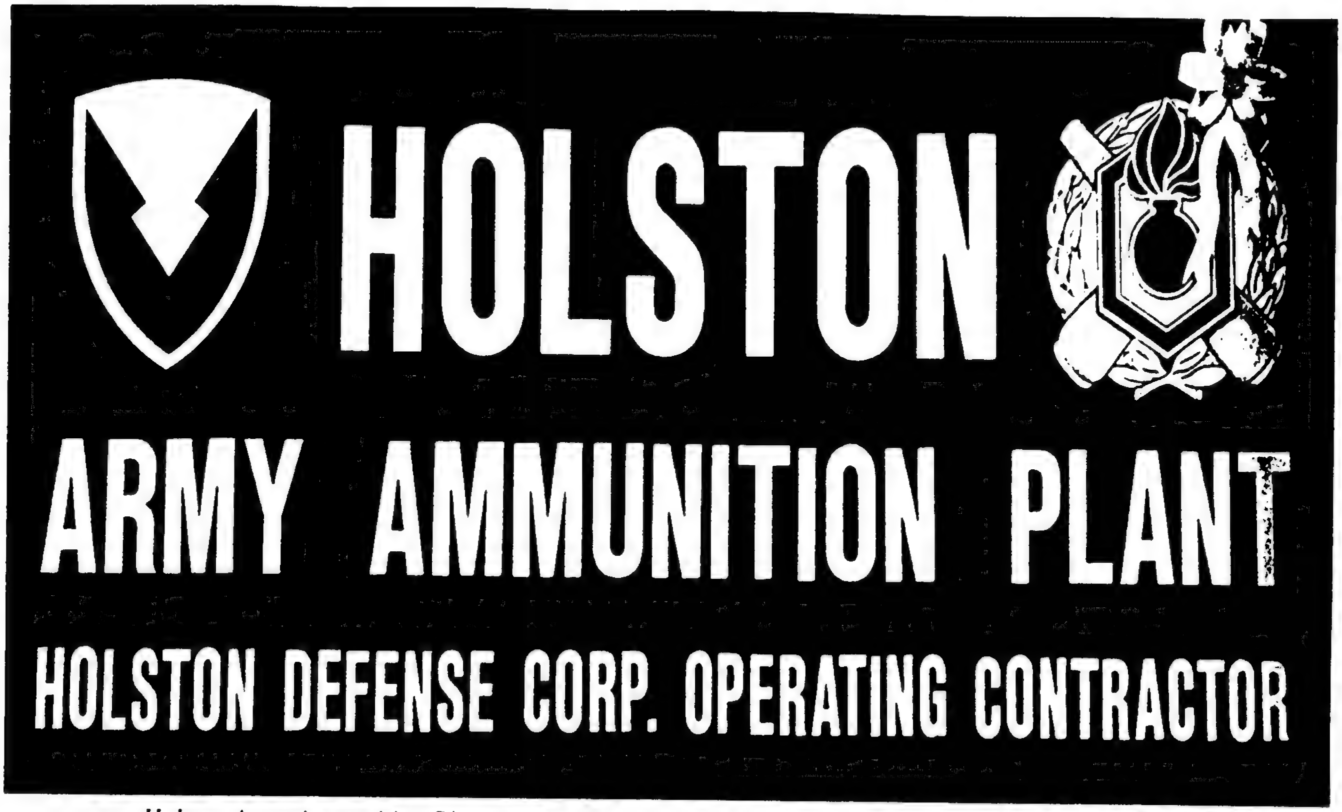
The following materials were furnished by the Holston Defense Corporation and are used with its permission.

Holston Army Ammunition Plant



Holston Defense Corporation

Operating Contractor



Holston Army Ammunition Plant is a U. S. Government-owned, contractor-operated facility for the manufacture of explosives.

Contents

............a partnership with the U. S. Government

Holston Army Ammunition Plant (HSAAP) plays an important role as a manufacturer of RDX (Research Department Explosive) and HMX (High Melting Explosive). HSAAP serves all branches of our Armed Services, and its products have been shipped to many Allies of the United States.

HSAAP is operated by Holston Defense Corporation (HDC), a subsidiary of Eastman Kodak Company.

HDC, like other Eastman companies, utilizes the principles of Quality Management to achieve continual improvement in all areas of operation.

Eastman Chemical Company
Quality Policy

QUALITY GOAL

To be the leader in quality and value of products and services

QUALITY MANAGEMENT PROCESS

- Establish mission, vision, and indicators of performance.
- Understand, standardize, stabilize, and maintain processes.
- Plan, do and reinforce continual improvement and innovation.

OPERATIONAL POLICY

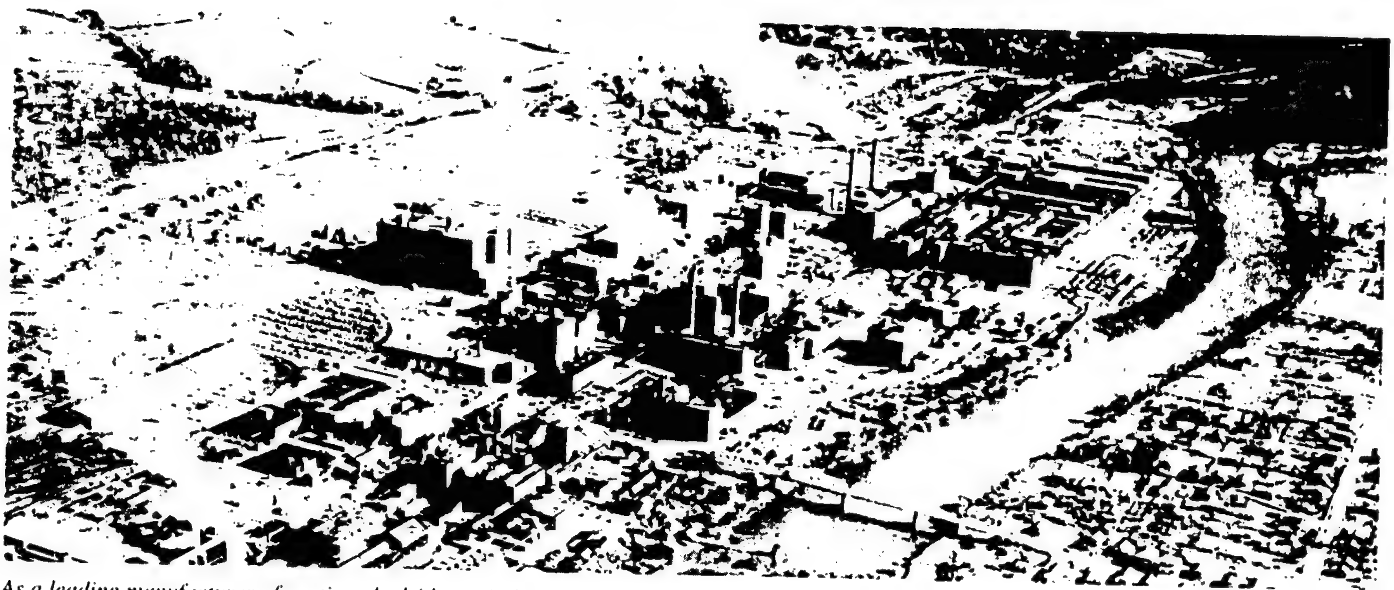
- Achieve process stability and reliability.
- Control every process to the desired target.
- Improve process capability.

PRINCIPLES WHICH SUPPORT AND ENABLE ACHIEVEMENT OF THE QUALITY GOAL

Customer Focus	Emphasize understanding, meeting, and anticipating customer needs.
Continual Improvement	Current level of performance can be improved.
Innovation	Everyone searching for creative process, product, and service alternatives.
Process Emphasis	Focus on processes as the means to prevent defects and improve results.
Management Leadership	Create an inspiring vision, maintain constancy of purpose, and establish a supportive environment.
Employee Involvement	Every employee participates in decision making and problem solving, along with teamwork among all functional areas and organizational levels.
Statistical Methods	All employees understand the concept of variation and apply appropriate statistical methods to continual improvement and innovation.
Performance Management	Take pride in work through clear accountabilities, feedback, reinforcement, and removing barriers.
Education and Training	Encourage learning and personal growth for everyone throughout their career.
Customer and Supplier Relations	Build long-term partnerships with customers and suppliers.
Assessment	Benchmark against world best and assess performance against the Quality Policy for improvement planning and reinforcement.

Ernie Deavenport

E.W. Deavenport, Jr.
President



As a leading manufacturer of acetic anhydride, a vital chemical in explosives, Tennessee Eastman Corporation (TEC) of Kingsport, Tennessee, became a key contributor to the World War II effort by producing RDX (Research Department Explosive).

When the U. S. Government urgently needed a highly effective explosive during World War II, they turned to Tennessee Eastman Corporation (TEC) of Kingsport, Tennessee. As a leading manufacturer of acetic anhydride, a vital chemical in explosives, Eastman became a key contributor to the war effort by producing RDX.

RDX had become crucial to the outcome of World War II, because German U-boats were able to withstand almost anything except a direct hit from a TNT depth charge. Virtually invincible, over 500 Nazi "supersubs" were effectively isolating Europe from all shipping. In the first seven months of 1942, 568 ships were sunk by U-boat torpedoes.

England and the U. S. urgently began to research a way to safely make large quantities of RDX - a sugar-like explosive which has more "punch" than TNT.

Dr. Werner E. Bachman at the University of Michigan found the answer with his "combination process". Instead of requiring huge amounts of nitric acid as did the old British "Woolwich process", this new process required (among other chemicals) acetic anhydride. Thus began Eastman's affiliation.

1942

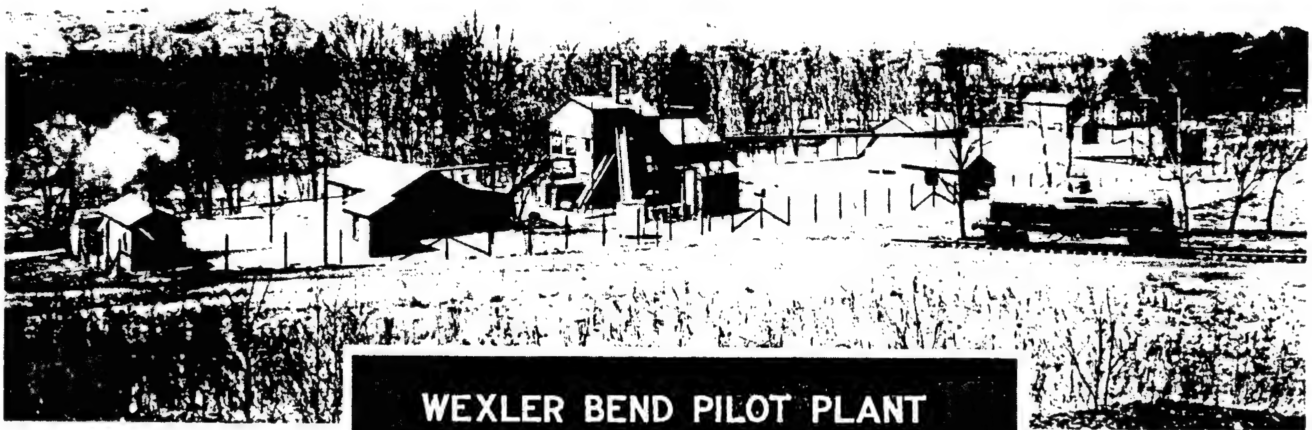
In February 1942, Tennessee Eastman Corporation became a major part of the war effort. A small Wexler Bend Pilot Plant, located in Kingsport, was staffed by 50 hand-picked TEC employees working day and night, on a round-the-clock operation. They produced small quantities of RDX high explosives, and this operation continued throughout the war.

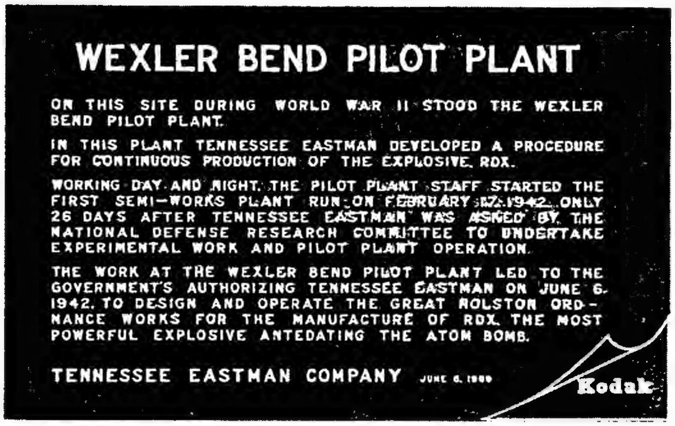
The work at the Wexler Bend Pilot Plant led, in June, 1942, to the U. S. Government's authorization of TEC to design and operate the Holston Ordnance Works (H.O.W.) for the manufacture of Composition B, the most powerful explosive prior to the atom bomb. Construction of H.O.W. began in June of 1942.

1943

On April 20, 1943, nine months after construction of H.O.W. began, explosives were being produced. This was timely, since Allied shipping to Europe was still only a trickle. The Battle of the Atlantic was on.

By June 1943, so many U-boats had been sunk with H.O.W. high-explosives that the German Navy admitted





The Wexler Bend Pilot Plant operation begun in February, 1942, was discontinued on May 21, 1943. Inset is a plaque erected by Tennessee Eastman Company in 1969 to mark the site.

they could no longer contain Allied supply lines. In September 1943, not a single merchant ship was sunk in the North Atlantic.

During 1943, design, construction and production were occuring simultaneously at H.O.W. Also, during this time, changes to the process were discovered which doubled the capacity to produce explosives.

1944

By January 1944, H.O.W. was producing and shipping about 570 tons a day of "Composition B."

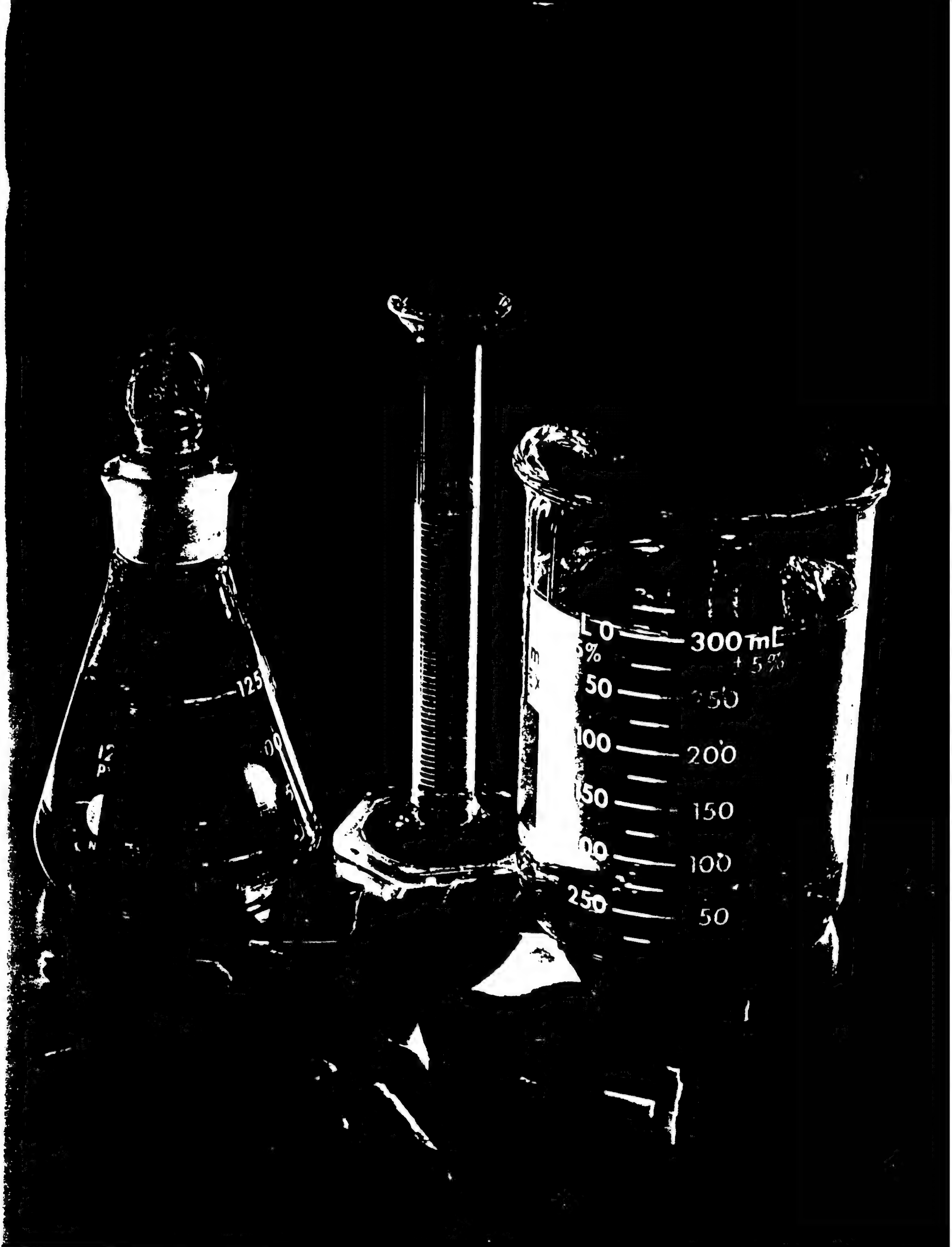
H.O.W. was mothballed at the conclusion of World War II. Holston Ordnance Works became Holston Army Ammunition Plant (HSAAP) when it was reactivated for the Korean Conflict. Significant explosives production was also required for the Vietnam Conflict.

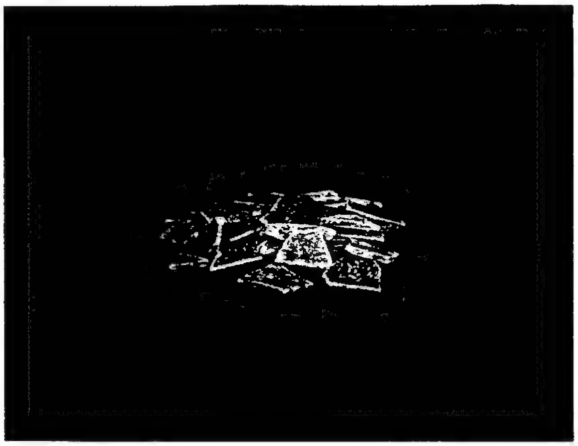
1990

In December 1990, HSAAP was asked to make Composition D-2 for use in Operation Desert Storm Navy bombs. These 2,000-pound bombs contained an explosive component, Composition B, which is mixed, or incorporated, with Composition D-2 (a non-explosive component), and aluminum.

There have been significant changes since construction in 1942. While HSAAP continues to make Composition B, the product line has expanded to over sixty-six different formulations, most based on either RDX or HMX.

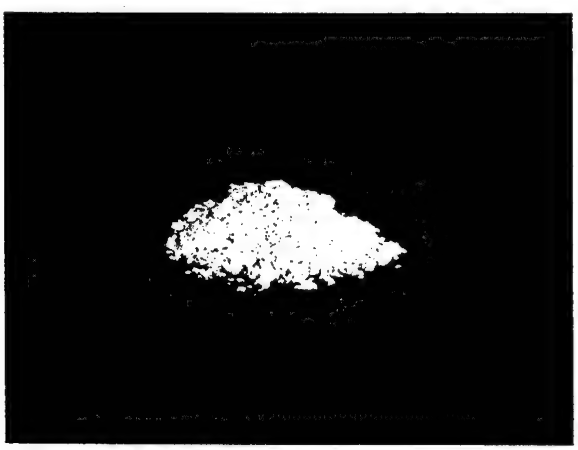
Today, as a wholly-owned subsidiary of Eastman Kodak Company, Holston Defense Corporation operates HSAAP. A continuing goal is to make production safer, to be more labor and energy efficient, to upgrade infrastructure of the utilities, and to have a positive impact on the environment.


125
300 mL
200
150
100
50



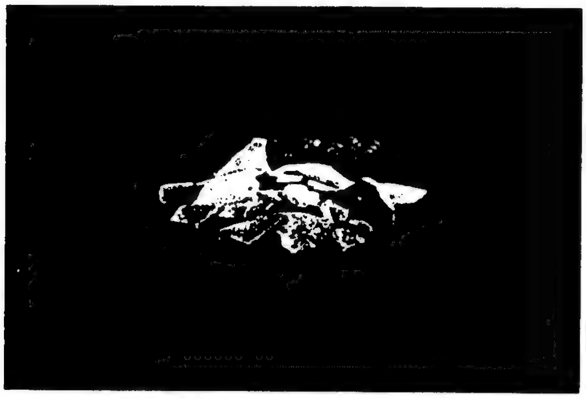
COMPOSITION B is used at the Milan AAP, in Milan Tennessee, as an explosive for the 81mm Mortar. It is also used at the Louisiana AAP, in Shreveport, Louisiana, for the 4.2" Mortar.

COMPOSITION A-5 is used at the Lone Star AAP, in Texarkana, Texas, as an explosive for the M77 Grenade, and the Multiple Launch Rocket System. Composition A-5 is also used at the Milan AAP, in the 40mm HEDP (High Explosive Dual Purpose) Grenade-launched system as well as in the 155mm M864 Abrams tank round.



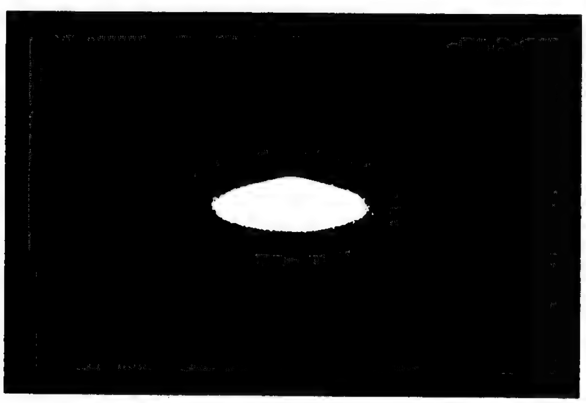
COMPOSITION C-4 is used at Louisiana AAP, in the Charge Demolition MICLIC. It is rope wrapped with detonating cord and C-4 packets. This is used to clear mine fields.

CXM-7 is used at the McAlester AAP, in McAlester, Oklahoma in the MK83 bomb.

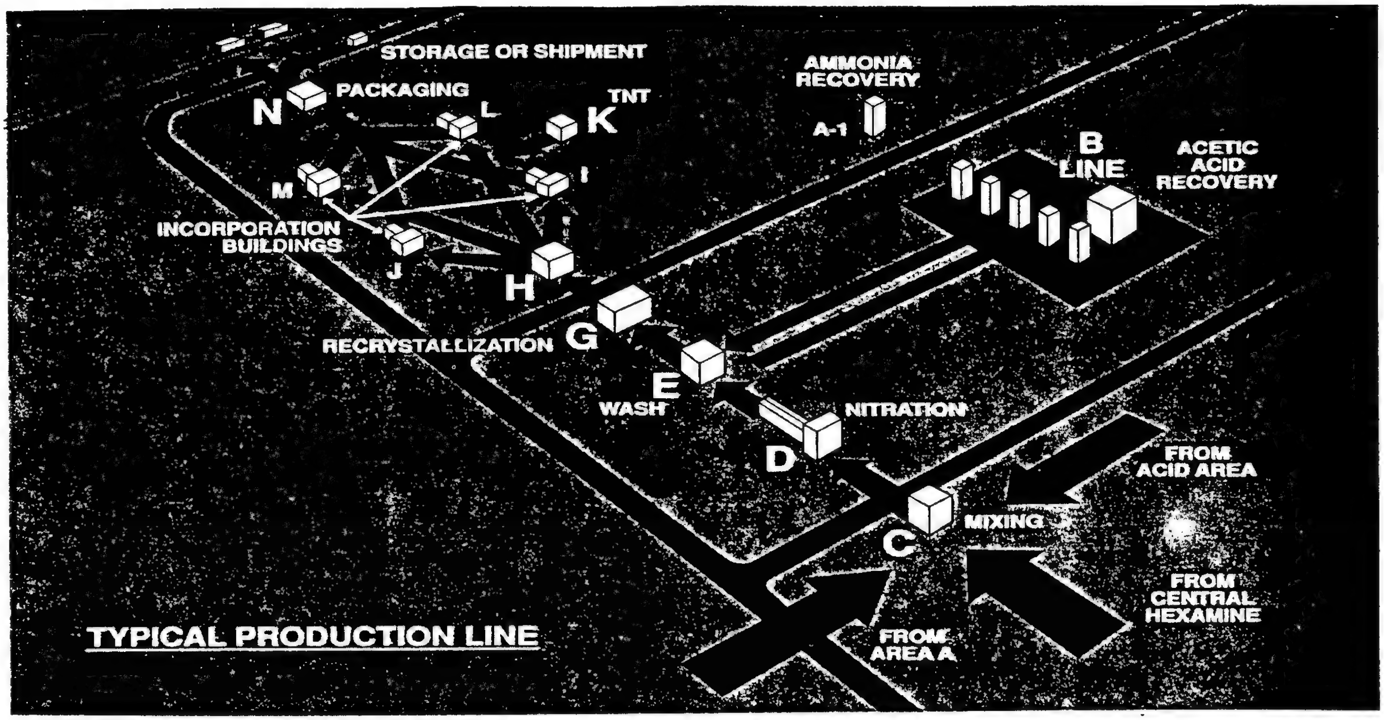


OCTOL is used at the Iowa AAP, in Middletown, Iowa in the I-Tow, and Tow-5, wire-guided anti-tank weapon systems. It is also used in the Stinger anti-aircraft, surface to air missle, and in the Hellfire anti-tank, air to surface missle from the Apache helicopter.

LX-14 is also used at the Iowa AAP, in the Stinger, Hellfire, I-Tow, and Tow-5 weapon systems.



HMX-80S is used at the Morton-Thiokol plant in Brigham City, Utah, as a propellent for the Trident missile system.



Schematic illustration of a typical production line

Explosives Production Process

1. Raw materials, including nitric acid-ammonium nitrate solution, hexamine-acetic acid solution, and acetic anhydride, are pumped to the "D" Building. They are fed into a centrifugal pump which serves as a quick mixing device. The vigorous, rapid reaction releases large quantities of heat.

   To control temperature, the pump discharges directly into water-jacketed pipe heat exchanger loops. As the solution circulates, nitrolysis takes place. Reactants return to the reactor and overflow into the age (or hold -up) tank, where the reaction is completed.

   Temperature is controlled with filtered water. The product overflows into a series of simmer tanks where it is diluted with water/weakened acetic acid, and the linear nitramines and other undesirable by-products are decomposed. The crude RDX slurry is cooled and pumped to the "E" Building.

2. RDX slurry is received in false bottom wash tanks; spent acid is removed, and the product washed with water. Continuous filters are utilized in a few of the "E" Buildings.

3. Washed explosive slurry from the "E" Building is pumped to the "G" or Recrystallization Building. The non-uniform, crude crystals of RDX contain a trace of acetic acid.

4. By partially dissolving the RDX in either acetone or cyclohexanone, the acid is reduced.

5. After dissolving, the solution is dropped by gravity through a screen to filter out foreign matter that would sensitize, or contaminate the RDX.

6. The filtered solution is distilled to gradually remove the solvent (which is recovered) and to reprecipitate the RDX in a water medium under conditions which control particle size distribution.

7. Generally, each "G" Building contains four dissolver-still systems. RDX is pumped to the "H" or Dewatering Building.

8. After being pumped in a water slurry into receiving tanks, RDX is dropped to stainless steel nutsches. Perforated stainless steel probes, covered with a cotton filter cloth, remove the water by vacuum filtration. It is now a Class 1.1 explosive.

9. The nutches, filled with RDX in final form, are transported to one of the incorporation buildings using electrical transporters.

10. Dewatered RDX is shoveled from the nutsche into an agitated kettle of molten TNT using a nonmetallic shovel. After excess water is decanted from the surface, the batch is heated until all moisture is removed.

11. Melted wax is added as a desensitizer. The molten Composition B flows from a casting pot onto a casting belt. Composition B is delivered to the "N", or Packaging Building, where it is boxed.

12. After it is boxed and weighed, the product will go directly to rail or truck docks, or to storage magazines.

MODERNIZATION

HMX control room

In the early seventies, the U. S. Army Armament Material Readiness Command embarked on an extensive modernization program. The purpose of the program was to install up-to-date technology and materials handling equipment at Holston.

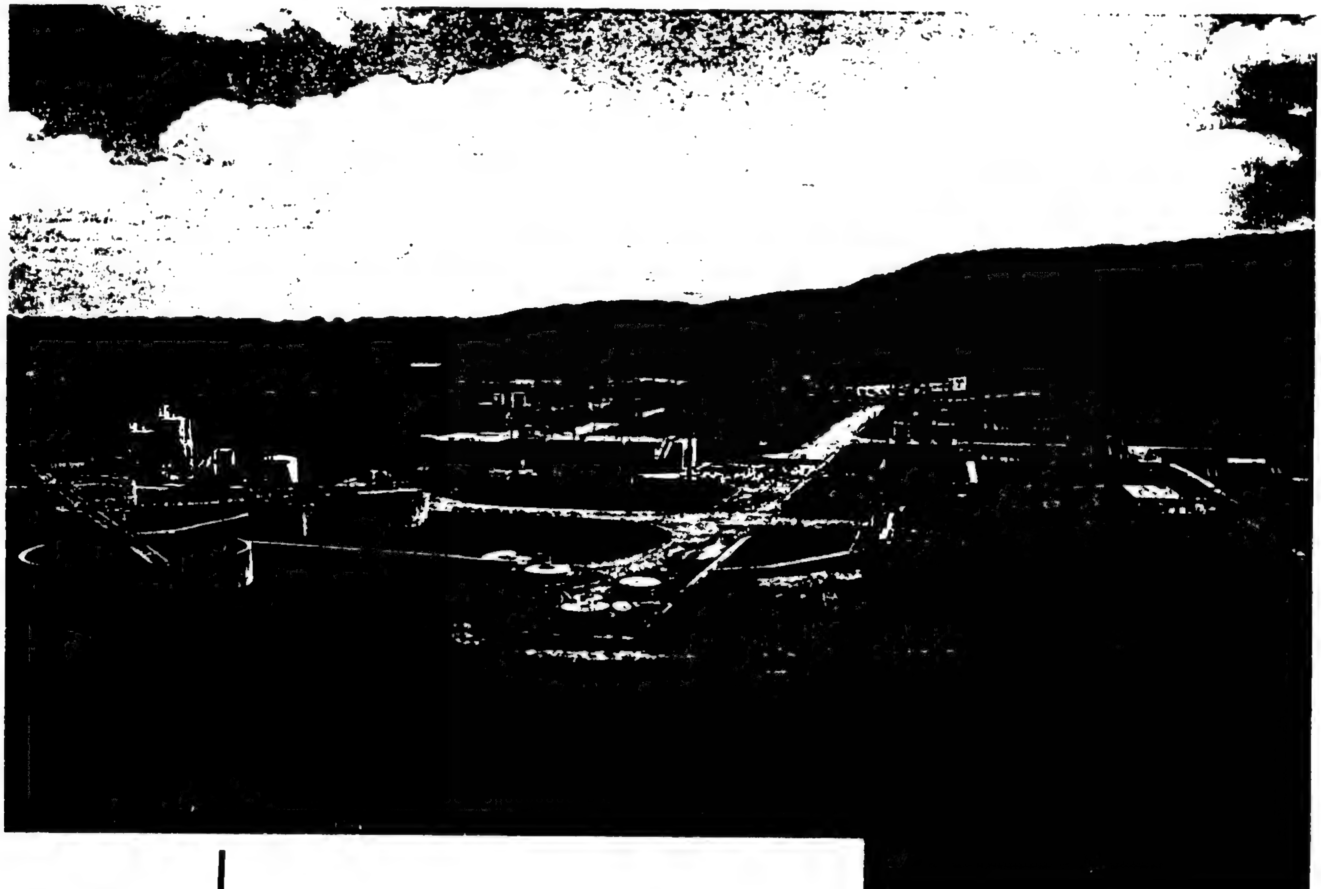
Projects completed in the seventies include:

- Continuous Composition B production line
- Central Solvent
- Central Lacquer
- Central Hexamine
- New administration building
- 300 ton-per-day weak nitric acid plant
- Maintenance shop for explosives plant
- Upgrading of all railroad track

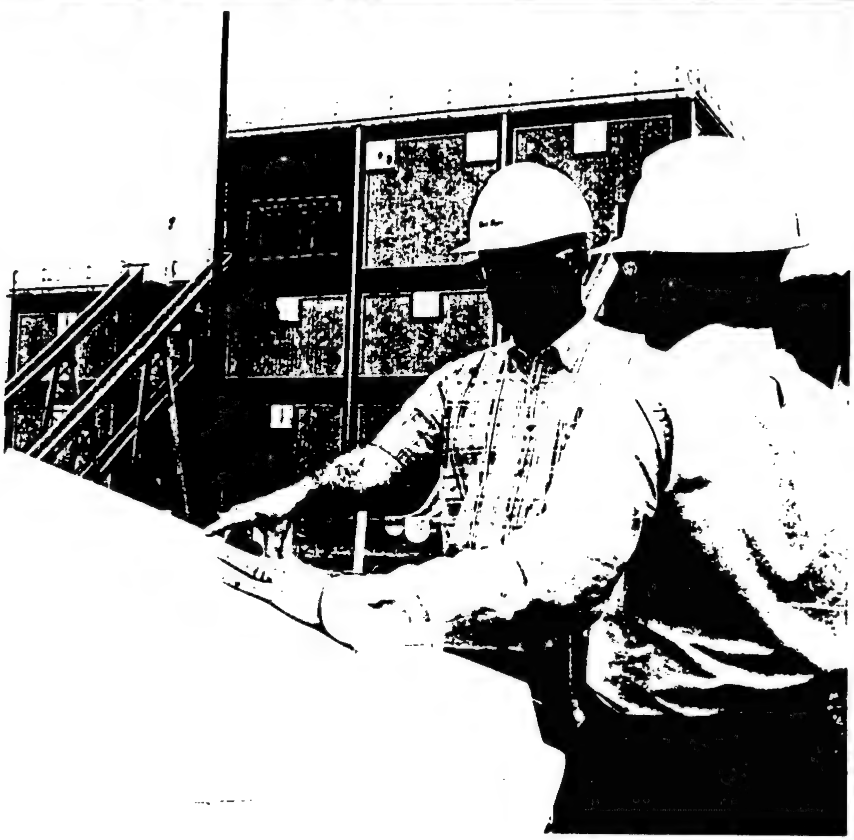
Projects completed in the eighties include:

- Coal handling modernization
- Line 8 for Composition C-4
- Line 10 for Composition A-5
- Loading dock

These projects, plus additional planned projects, call for a modernization effort that will affect virtually all of the remaining inactive production lines at Holston.



Wastewater treatment plant



Not all of the major improvements underway at Holston are due to modernization. In 1986, the Army funded a reactivation project to correct deficiencies and to reactivate, modify, and convert existing facilities to ensure a continuing capability to manufacture the products required by the production schedules. The schedules modify both the rates of the various explosives products and the ratios of the products, one to another. The scale of this reactivation effort is such that by the mid-nineties, very few processes will remain unaffected by modernization or reactivation.

The highest priority of Holston Defense Corporation in operating Holston Army Ammunition Plant is safety - safety expectations, safety procedures, and written safety practices.

Based on the Corporate Safety Policy, expectations for safe behavior and conditions are defined and communicated to all employees, contractors, and visitors.

Procedures provide for a safety review of new and modified buildings and equipment during design, construction, and commissioning. Written safety practices cover work situations requiring specific safety precautions.

This philosophy and emphasis result in a work environment that is consistently among the safest in the industry. There have been numerous periods when more than a million employee hours have been worked without an OSHA Lost Workday Out Injury, including a plant record of 6,175,079 hours.

Wastewater treatment plant control room

Energy conservation at HSAAP is more than turning off the lights when leaving the office. Energy conservation is everyone's responsibility, and Holston Defense Corporation employees take it seriously.

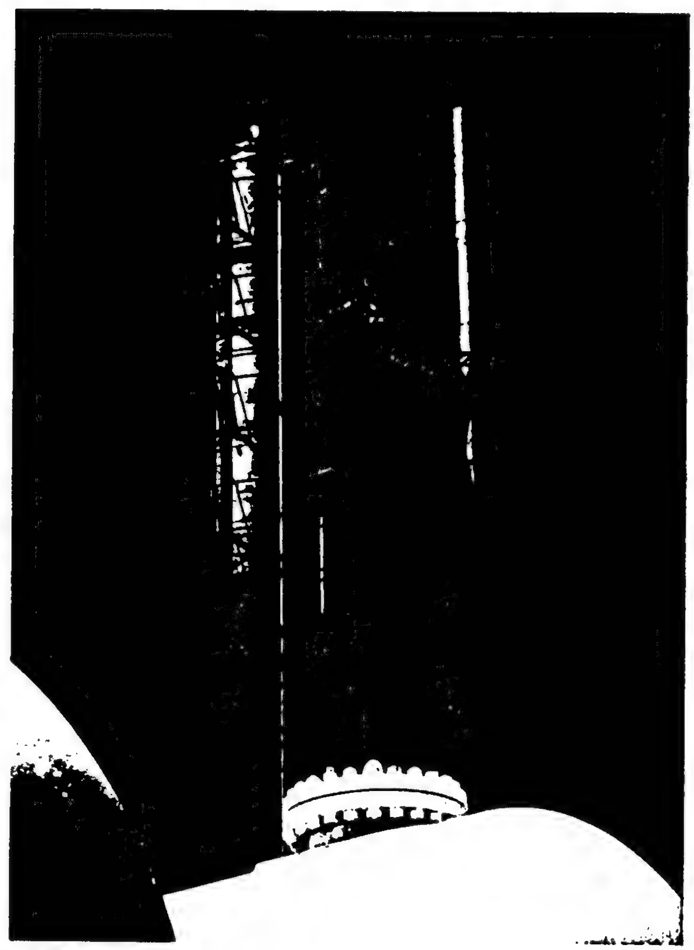
Guided by the Energy Committee (a team of service and production managers) and administered by a full-time Energy Coordinator, the HDC Energy Conservation Program has reduced plantwide energy consumption by 17.9 percent per pound of product over the past four years.

Since 92 percent of all energy consumed at HSAAP in terms of BTUs comes from coal, improvements in boiler operation and steam utilization have yielded (and continue to yield) the biggest returns. Some of these projects include analyzing boiler combustion, eliminating steam boxway heating, buying higher quality coal, using more efficient steam traps, and reducing steam pressure through electricity-generating turbines, instead of through pressure reducers.

"Substantial steam savings," reports one manager, "have come by 'vigilance in watching the control charts'."

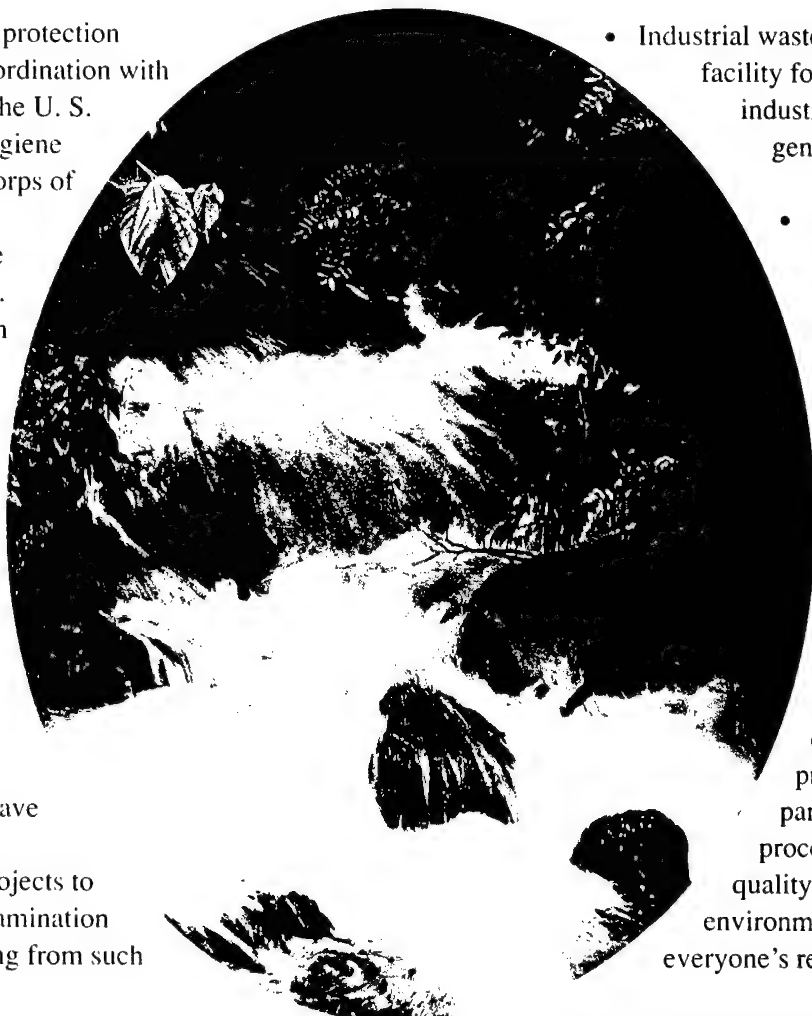
Once a year, a plantwide focus on energy conservation is achieved through Energy Awareness Week. Employee excitement through contest participation challenges everyone to find answers and become more energy-conscious.

Electricity consumption accounts for 25 percent of the HSAAP energy dollar. Prudent operation of large motors, such as those used to drive river water pumps, reduces costs. In addition, the gradual plantwide replacement of small motors with energy-efficient motors contributes to the overall belief that energy conservation is the most cost-effective energy source at HSAAP.



ENVIRONMENTAL PROTECTION

Holston Defense Corporation's policy is to protect the environment from any harmful air, water, or solid waste discharges occurring as a result of operations. Emissions are eliminated where practical; and if they are not eliminated, efforts are made to achieve the minimum, feasible level (below those set by regulation). Also, the volume and toxicity of wastes are kept at the minimum feasible level.



Holston's environmental protection activities also require coordination with Army agencies, such as the U. S. Army Environmental Hygiene Agency and the Army Corps of Engineers. Excellent working relationships are maintained with the U. S. Environmental Protection Agency, Tennessee Department of Health and Environment, Divisions of Air Pollution Control, Water Pollution Control, and Solid Waste Management, local community governments, and citizens.

Environmental surveys have been conducted to define problems and develop projects to correct or eliminate contamination sources. Projects resulting from such surveys are:

- Electrostatic precipitators for particulate (flyash) removal from 13 coal-fired boilers
- Bag houses on the flyash handling system at the steam plants
- Refuse incinerators for the elimination of open burning of materials that have not come into contact with expolsives products.
- Dikes around chemical storage tanks to prevent accidental discharges from reaching the Holston River
- Process modifications for the control of NOx from the nitric acid manufacture and concentration units
- Water monitoring system
- Industrial wastewater treatment facility for the treatment of all industrial wastewater generated at Area A and B
- Purchase of a water truck to wet down unpaved roads to reduce fugitive dust
- Paint solvent recovery unit

Production departments have conducted extensive operator training programs to make environmental protection as much a part of the manufacturing process as safety and quality. The task of environmental protection is everyone's responsibility.

Future plans for environmental protection at HSAAP are centered around an on-going evaluation of all operations to keep HSAAP in compliance with existing regulations. All pending and future environmental regulations are monitored in order to provide as much lead time as possible to implement changes to maintain compliance.

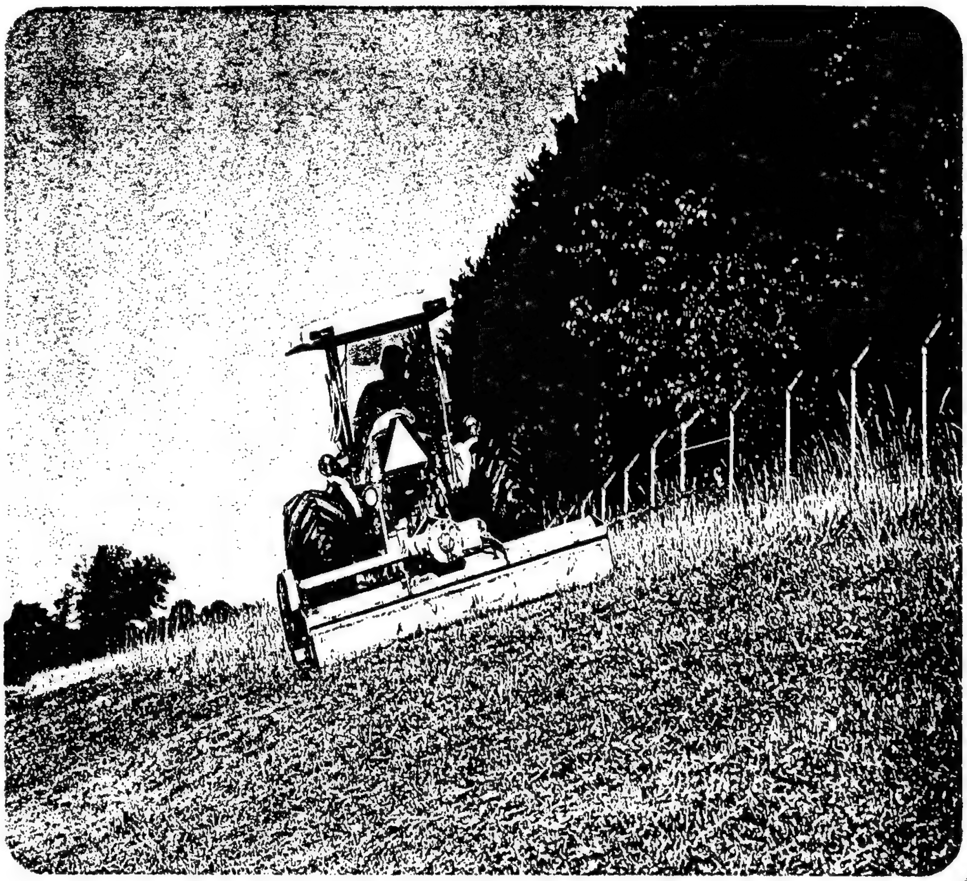
The Natural Resource Management effort at HSAAP includes the following:

1. Forest Management
2. Fish and Wildlife Management
3. Grounds and Land Management
4. Recreation Management

The underlying objective of our Natural Resource Management Program is to balance the management of our natural resources environmental quality, ecological relationships, and aesthetic values with the needs of our military mission. HDC intends to be a good steward of the 6,025 acres of land and resources with which it is entrusted.

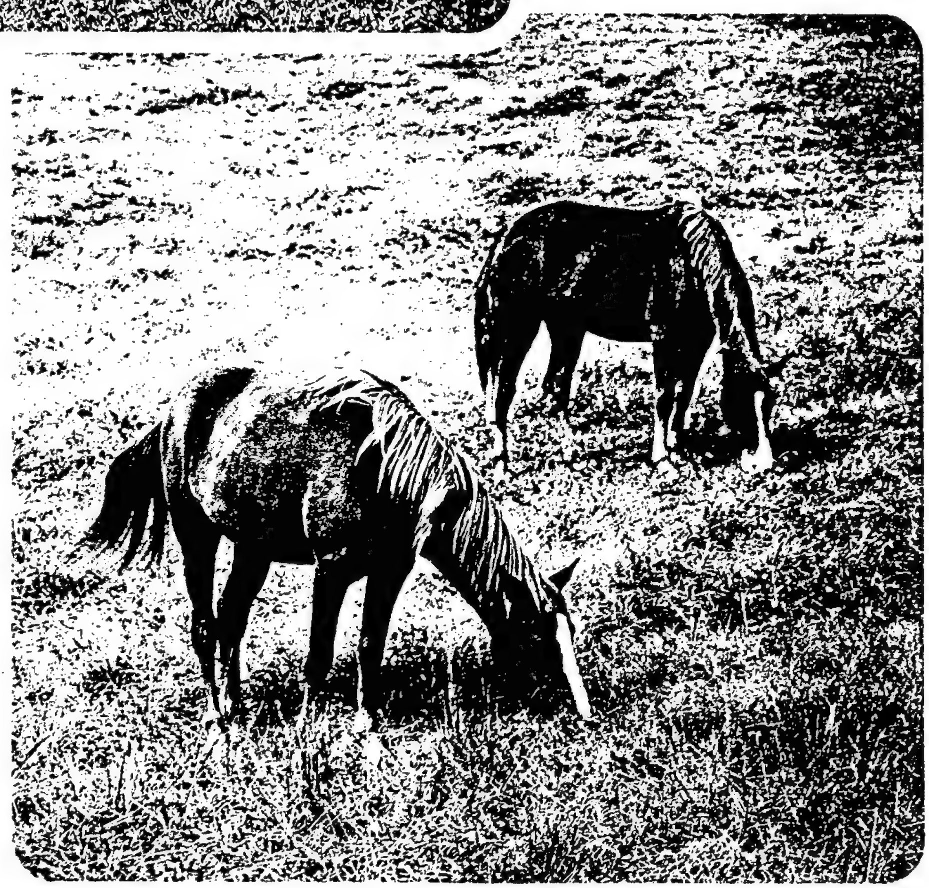
The Forest Management Program is a long-range plan for the development and harvest of the 3,800 acres of forest on the installation. Most of the forest covers the rugged north slope of the Holston River Mountain that forms a majestic backdrop to the entire production facility. The total volume of forest products is estimated at 9,800,000 board feet, including pine, cottonwood, black walnut, and natural hardwoods. The HSAAP program includes thinning of pines and cottonwoods, making improvement cuttings to the hardwoods, and reforesting of specific areas.

The purpose of the Fish and Wildlife Management effort is to preserve a balance of wildlife, to enhance their habitat, and to promote the general appreciation and proper utilization of this resource. The habitat for fish and wildlife on the installation includes one four-acre lake; approximately 15 miles of shoreline along the Holston River; and various forested areas and maintained grounds within the 6,025-acre facility. Deer, turkey, geese, ducks and a wide variety of small game abound on the installation. HSAAP is opened periodically to organized hunting in cooperation with rules established by the Tennessee Wildlife Resources Agency.



The Grounds and Land Management effort involves the upkeep of the improved grounds, the area around the production buildings, the ammunition storage areas, road shoulders, firebreaks and both sides of the perimeter fences, as well as the lease of 571 acres in row crops and pasture. Maintenance of grounds is performed by both an in-house crew and subcontractor labor. Presently, six agricultural areas are leased for three-year intervals, reducing in-house maintenance efforts and providing income to the government. These leases also provide a habitat for our wildlife.

The Recreation Management Programs at HSAAP are somewhat limited due to the military nature of our mission. However, employees are allowed to jog and walk in designated areas, and they may use an archery range or softball field. Outside organizations may participate in guided wild flower and bird-watching activities, if approved in advance by the plant commander. The fall colors, winter snow, and spring foliage that seasonally envelop the installation provide a source of grandeur enjoyed by all who view it.



ERRATA FOR HOLSTON ARMY AMMUNITION PLANT BROCHURE

The following corrections are provided for Products & Customers listed on pages 6 and 7 of the Holston Army Ammunition Plant Brochure:

COMPOSITION B is used at the Milan AAP in Milan, TN, as the high explosive fill in the M720 (60 mm) and M374 (81 mm) series mortar cartridges. Composition B is used at the Louisiana AAP in Shreveport, LA, as the high explosive fill in the M329A2 (4.2 in) mortar cartridge and the M107 (155 mm) artillery projectile. Composition B is a major component of the H-6 explosive (aluminized Comp B) which is loaded in the MK80 series of bombs at McAlester AAP in McAlester, OK.

COMPOSITION A-5 is used at the Lone Star AAP in Texarkana, TX, as the main charge in the M42 and M46 grenades contained in the M483 (155 mm) artillery projectile. Composition A-5 is also used at Lone Star AAP in the M77 grenade contained in the MLRS (Multiple Launch Rocket System). Composition A-5 is used at the Milan AAP in the M42 and M47 grenades contained in the M864 (155 mm) and the M509 (8 in) artillery projectiles and in the 40 mm HEDP (High Explosive Dual Purpose) cartridge.

COMPOSITION C-4 is used at the Louisiana AAP in the M112 demolition block and in mine clearing line charge (MICLIC). The MICLIC system is comprised of nylon rope wrapped with detonating cord and C-4 packets. It is used to clear mine fields.

CXM-7 is used at the McAlester AAP in McAlester, OK, in the MK83 bomb.

OCTOL is used at the Iowa AAP in Middleton, IA, as the main charge in the TOW and I-TOW wire guided anti-tank missle systems. Octol is also used in the STINGER anti-aircraft surface-to-air missle and the AT-4 anti-tank missle system.

LX-14 is used at the Iowa AAP as the main charge in the TOW-2 series and HELLFIRE anti-tank missle systems. The HELLFIRE is an air-to-surface missle which is among the primary armament for the APACHE helicopter.

HMX-80S is used at the Morton-Thiokol plant in Brigham City, UT, as the propellent for the TRIDENT missle.

The Holston Defense Corporation, subsidiary of Eastman Kodak Company, and the prime contractor for the U.S. Government at Holston Army Ammunition Plant, and the U.S. Army Armament Material Readiness Command do not assume any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of the suitability of any information or material for use contemplated, the manner of use, and possibility of patent infringement is the sole responsibility of the user. Descriptions of the materials described does not constitute an offer or obligation to supply any such material.

US ARMY
ARMAMENT
MUNITIONS
CHEMICAL COMMAND

Final Technical Report

SERDP Project Number CS-1068
P Number 96pr06634-02

Section II
Environmentally Benign Energetics Synthesis Methods
ONR Grant Number N000149611067 (in part)

Dr. Tye Barber, Dr. Rajender Varma and Dr. Benny Arney

Texas Research Institute for Environmental Studies
College of Arts & Sciences
Department of Chemistry
Sam Houston State University

FINAL PROGRESS REPORT

Introduction

New energetic materials are under development which offer many advantages to US Department of Defense (DoD) applications. For these materials to be of practical use, they must produced in cost effective manner. In addition, the production of these energetic materials must have a minimum impact on the environment. To meet the needs of critical DoD missions within the budgetary and environment constraints, superior synthetic procedures are needed. Currently synthetic methods for TNAZ (1,3,3-trinitro azetidine), CL-20 (Hexanitrohexaazaisowurtzitane), and difluoramine energy material have low yields and produce unacceptable quantity of hazardous waste.

Dr. Arney's Group Report

TNAZ

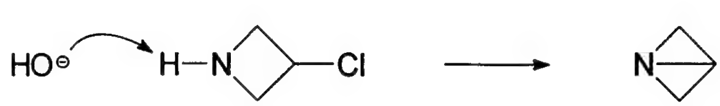
Investigation of Elimination Process Involved in the Generation of 1-Azabicyclobutane.

The crucial road-block in the utilization of the Azabicyclobutane Process to prepare TNAZ has been the inefficient conversion of precursors to 1-azabicyclobutane. Dave (personal communication via A. P. Marchand) et al (ARDEC), has made dramatic improvements in the yields of the N-nitroso-3-nitroazetidine from 1-azabicyclobutane prompting us to examine the elimination process leading the formation of the 1-azabicyclobutane moiety. We investigated the process computationally and experimentally via ^{1}H and ^{13}C NMR of the reaction in D_2O over time.

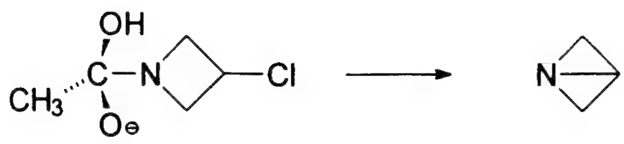
Computationally, we examined the possibility of locating transition states leading to the formation of 1-azabicyclobutane from several intermediates. The intermediates chosen were as follows:

I. 3-chloroazetidinide:

II. hydroxide : 3-chloroazetidine complex:



III. hydroxide addition product to N-acetyl-3-chloroazetidine



Process **I**, being the simplest, was examined to determine if the azetidinide occupied a energy minimum and might therefore have a significant lifetime. No minimum could be found for the azetidinide at various levels of computation. It was observed that the result of geometry optimization was consistently the formation of the azabicylobutane. These results are strongly suggestive and we believe that the azetidinide is not formed as an intermediate in the generation of 1-azabicyclobutane and that any process which could potentially form this anion would instead lead to the bicyclic amine.

Process **II** exhibited expected behavior. Spatial placement of the hydroxide is particularly important to the progress of the optimization. We have not been successful in the elucidation of a single transition state for the forward reaction primarily due to the availability of "degenerate" processes, Figure 1, which are low energy and tend to lie close to the desired pathway producing higher dimension saddle-points. Though the transition state eluded determined, the computed behavior was consistent with that expected based on the results obtained in process **I**. Despite extensive computational efforts, our search produced no indications for the presence of an intermediate similar to the anion hypothesized in process **I**.

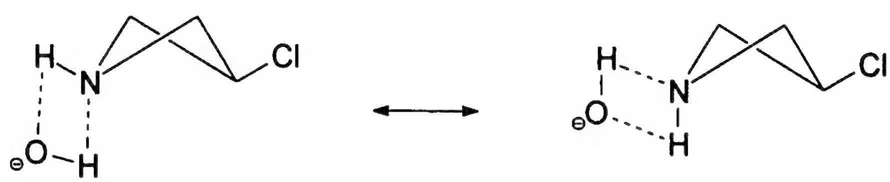
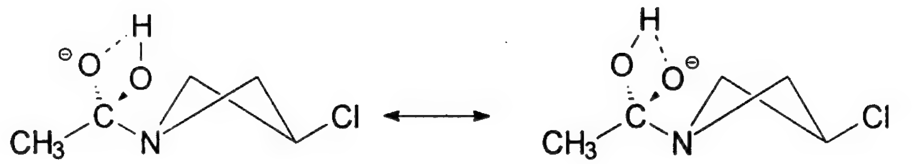
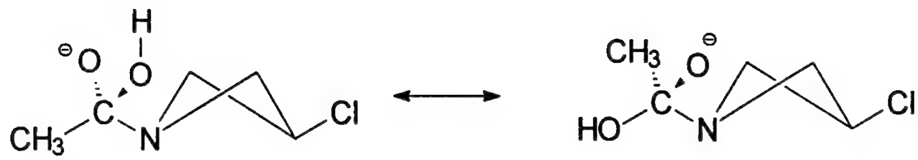


Figure 1

The third avenue of computational investigation of that shown above for process **III**. Addition of hydroxide to the acetyl carbonyl actually provides a computationally stable intermediate, as expected, which can be viewed as in equilibrium with both starting N-acetyl-3-chloroazetidine and with the expected bicyclic amine product. However, even a superficial examination of the products of the reaction shown above for process **III**, which yields chloride and acetic acid in addition to the bicyclic amine, reveals that the reaction to form the amine is irreversible since the acetic acid product is removed in the form of acetate due to the hydroxide reactant. Similarly to the case of process **II**, location of an appropriate transition state was hampered by the presence of low-energy processes which lie very close starting geometry and the transition state. In this instance, two types of processes were encountered: a degenerate proton migration and conformational rotations about the exocyclic C-N bond. However one transition

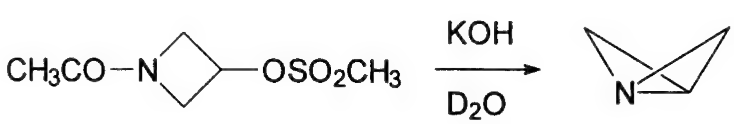




state was encountered which led to the expected bicyclic amine.

All of the calculated transition states share a common feature when on the path to azabicyclobutane. In every case, the carbon-chlorine bond is very far along the path to being broken prior to significant transannular bond formation. This information leads to some extremely significant and leading conclusions. First, the transannular cyclization occurs in a concerted manner from a species much like that hypothesized for process **III**. In these computational experiments, we did not encounter the appearance of alternative processes which would lead to side-products. Now this would be partially due to the design of the experiments, but often competing concerted processes appear in the optimizations, especially from transition states. For the production of 1-azabicyclobutane, the above results strongly indicate the process is very clean and energetically favorable, suggesting that the problems of yield arise from the conditions used to drive the reaction to completion and the effects of these conditions on the bicyclic amine produced.

In light of the statements above, we have been performing, and continue to perform, the transannular cyclization reaction under direct observation in an NMR tube. N-acetyl-3-methanesulfonoxyazetidine is used as the precursor to 1-azabicyclobutane because of its ready preparation, reactivity, and simple NMR spectra. A solution of the precursor in D_2O is treated with KOH, also dissolved in D_2O, in an NMR tube. The sample is observed by ^1H and ^{13}C NMR at intervals over periods ranging from hours to days at ambient temperatures. Our initial



observations revealed a clean production of the bicyclic amine with no observable side-products. We noted that the rate of the conversion of precursor to amine dropped off dramatically as the reaction progressed demonstrating a strong dependence on the concentration of hydroxide and precursor. No detectable production of the amine was noted in the absence of base. Controlled kinetic studies are being initiated to determine the order and rate constants for the reaction.

Continuing Work:

Important to the application of this reaction is the observation that degradation of the bicyclic amine is a slow process at ambient temperature, but appears to be auto-catalytic. We note that disappearance of the bicyclic amine appeared to increase in rate with the buildup of the decomposition products. We believe our observation of the differences on kinetic behavior for the reaction to produce the amine versus the reaction to decompose the amine will be useful to the optimization of this process as we determine the details in more controlled experiments.

Progress on Continuous Flow Electrochemical Nitrosation Reactor:

Improvements in the ongoing development of a electrocatalytic silver nitrite reactor system for continuous flow production have been made. Continuous extraction of liberated dinitro- compound has been demonstrated using the standard conditions stated in previous reports. Current-efficiencies for the reactions have been maintained at their very high levels (<85%). Denser than water organic solvents suitable for this task are few and currently dichloromethane has been the solvent of choice. Characteristics deemed important are:

1) Low water solubility.
2) Low boiling point.
3) Density greater than 1.15 g/cm^3.
4) Insensitivity to base (pH of reaction conditions 9.5 < <11.5)
5) Insensitivity to anodic oxidation.
6) Moderate polarity

Examination of the extracts generated in these runs show a marked reduction in the formation of the dimeric side-products which accompanies most nitronate oxidations. Nitronate and mononitro compounds were not found to be present in the extract as might be feared. In our hands, the resulting dinitro compound isolated by simple removal of solvent was of >95% purity.

An inverse extraction system utilizing solvents of lower density than water is under examination currently. The primary impetus for this type of system is the removal of environmentally-antagonistic halogenated organic solvents from the process. At the current point, an operational flow system is in place and preparations for actual reactor runs with this inverse extraction system are being performed. Solvent selection adheres to the criteria noted above with a density less 0.95 g/cm^3. At these lower densities, the selection of suitable solvents is very problematic. Most solvents of low boiling point and moderate polarity are too water soluble. Diethyl ether is plagued with its inherent high flammability-volatility. Our initial runs will utilize diisopropyl ether as the extraction solvent because of its reduced volatility and water solubility, relative to diethyl ether, and its current market price is lower per liter than for diethyl ether.

PROPOSED FUTURE WORK :

Future Continuing Work on the Utilization of Environmentally Benign Electrochemical Processes for Elimination of Waste and Hazardous Material Production:

A. Examination of the use of a zinc/zinc nitrate cathode is under investgation for replacing our current cathode. Zinc does not appear to have any interaction in the nitronate-nitrite reaction system like many metals which promote the formation of dimeric compounds. Zinc also does not form hydrated basic nitrite salts which can lead to problems with precipitation at the interface.

B. Effort will continue on the development of a salt removal unit to remove the potassium nitrate which is generated in the reaction and which builds ups. If the potassium nitrate is not removed from the system on a continuous basis, salt build up will necessitate the shutdown of the system to replenish the reaction medium. That essentially means going back to a batch process. A scheme for the removal of salts is being developed which can also be piggy-backed as a delivery system for maintaining the nitronate concentration at reaction levels. The system under development will use a temperature gradient to remove the excess salt in a collection chamber which may be switched in or out of the flow circuit. This temperature gradient strategy may also provide the capablility to maintain a constant nitronate concentration entering the anode reactor.

C. The general efficacy of this system will be further explored using nitronates of greater and lesser hydrophilicity than the current model of potassium isopropyl nitronate.

D. Electrochemical alternatives to several fundamental processes which generate tremendous hazardous waste streams are being examined and investigated, such as:

iv. Oxidation N-nitroso groups to nitramines.
v. Oxidative nitrite addition to oximes providing geminal dinitro groups.
vi. Electrochemical nitrosation of dialkyl amines to nitramines.

Dr. Varma's Group Report

TNAZ

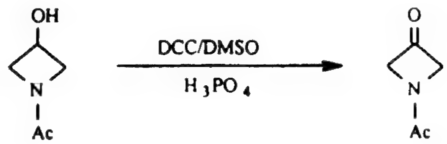
TNAZ has been identified as an important new energetic material that finds numerous applications in explosive and propellant technology. The melting point (101 °C) and good thermal stability of TNAZ makes it a valuable energetic material.

Experiments Performed and Results

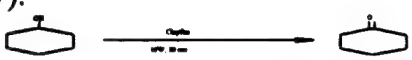
The experiments were performed for the improvement in the efficiency of TNAZ preparation.

N-Acetyl-3-hydroxyazetidine was oxidized by Pfitzner-Moffatt oxidation method using DCC-DMSO-H_3PO_4 (Pfitzner, K.E.; Moffatt, J.G. *J. Am. Chem. Soc.* **1965**, *87*, 5661,5670) to give N-acetylazetidin-3-one, but the yield was very poor (~15 %). The Infrared spectrum of the product shows an absorption peak at 1830 cm^{-1} and NMR shows a singlet at 2.5 ppm for -

$COC\underline{H}_3$ and two broad singlets at 4.5 and 4.7 ppm for two protons each ($-C\underline{H}_2$) in the azetidine ring.



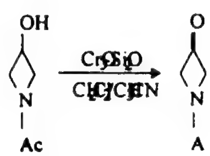
The use of iron(III) nitrate impregnated montmorillonite K 10 clay (Clayfen) as an oxidizing agent was explored. Clayfen has been used as an oxidizing as well as a nitrating agent in solution phase by Laszlo *et al.* (*Synthesis* **1985**, 909). We conducted the oxidation of cyclohexanol by clayfen as a model compound since it possesses a secondary alcoholic group, a typical of N-acetyl-3-hydroxyazetidine, and was oxidized in just 30 seconds (Varma *et al.* Tetrahedron Lett. **38**, 2043, 1997).



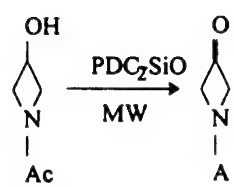
Consequently, we considered it worth our while to oxidize N-acetyl-3-hydroxyazetidine with clayfen. We conducted these reactions in solution phase ($CHCl_3$, CH_2Cl_2, and CH_3CN), but could not get the desired products.

However, when the azetidinol was mixed with clayfen in solid state at room temperature, the substrate was converted into an unidentifiable gummy product, which does not contain acetyl group or a keto group as revealed by IR spectrum.

Since the organic reactions on solid supports occur fast in high yields and the solid support can be recycled, we decided to oxidize N-acetyl-3-hydroxyazetidine with new methods developed in our laboratory such as active MnO_2-silica (Varma *et al.* Tetrahedron Lett. **38**, 7823, 1997), and iodobenzene diacetates on alumina (Varma *et al.* Tetrahedron Lett. **38**, 7029, 1997) and CrO_3-doped silica gel (Varma *et al.* Tetrahedron Lett. **38**, in press, 1998).

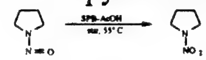


N-Acetyl-3-hydroxyazetidine was oxidized to give N-acetyl-3-azetidinone in only ~20 % yield with CrO_3-Silica. Similarly, we obtained poor yields with other reagents too. We, also, carried out the oxidation of N-acetyl-3-hydroxyazetidine with pyridinium dichromate (PDC) 'doped' silica gel.



N-Acetyl-3-hydroxyazetidine was oxidized by PDC-silica to give N-acetyl-3-azetidinone in only ~40 % yield using microwaves (MW) under solvent-free conditions. The environmentally benign aspects of this methodology is obvious since it avoids the use of large excess of organic solvents.

Keeping in view the similarity in structure with azetidine, we tried the oxidation of N-nitrosopyrrolidine to give N-nitropyrrolidine. Literature methods are available for the oxidation of nitrosobenzene to nitrobenzene [McKillop, A. and Tarbin, J. A., *Tetrahedron*, **1987**, *43,* 1753] using sodium perborate in glacial acetic acid. Following the same procedure, N-nitrosopyrrolidine could be oxidized to N-nitropyrrolidine in about 50 % yield.



In another oxidative exploration, N-nitrosopyrrolidine could be oxidized to N-nitropyrrolidine in about 70 % yield using benign sodium perborate (SPB) in acetic acid (AcOH) with a catalytic amount of chromium trioxide (CrO_3) that improves the overall process of oxidation, but this method also failed with N-Acetyl-3-hydroxyazetidine

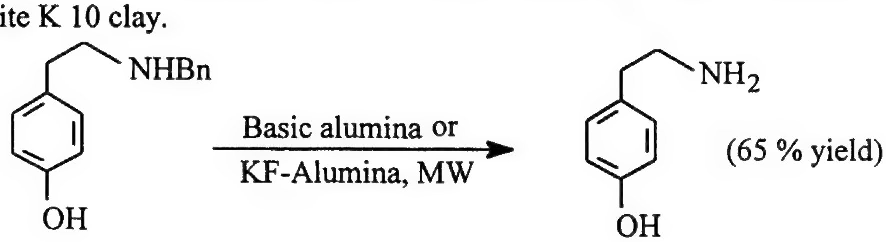
CL-20 (Hexanitrohexaazaisowurtzitane)

Literature search pertaining to the debenzylation reactions and debenzylation on solid support was conducted

Experiment Performed , Results and Discussion

1) Debenzylation reactions on solid surfaces under solvent free conditions:

In view of the successful cleavage of various functional groups in our laboratory, under solvent-free conditions, we explored the possibility of debenzylation of some model compounds on solid surfaces under the influence of microwave irradiation. A variety of solid support surfaces namely SiO_2, Al_2O_3, clays etc. were investigated under solventless conditions. In summary, we found that N-benzylaniline, N-benzyl tyramine etc. could be deprotected within 10 min. by microwave irradiation on basic alumina, and KF-Supported alumina in 65% yield. The cage compound, however, underwent decomposition when subjected to microwave irradiation on these of solid surface namely silica, neutral alumina, basic alumina, KF-alumina, montmorillonite K 10 clay.

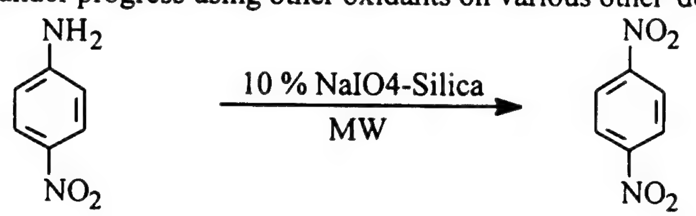


2) Alternative methods for synthesis of caged compounds:

Attempt were made to synthesize the cage compound by starting from the hydrazine derivatives with a view that N-N bond is cleaved easily by employing $NH_2NH_2.HCl$ to afford amino groups. The amino groups can be subsequently oxidized to nitro functionality by known literature methods. Various hydrazine's, such as N,N-dimethyl hydrazine, phenyl hydrazine and N-aminophthalamide were used under the conditions described earlier by Nielson *et al.* for the synthesis of cage compound. In the case of phenyl hydrazine and N,N-dimethyl hydrazine only hydrazone was obtained. However, in the case of N-aminophthalamide, we generated an unidentifiable product that is not soluble in most of the common organic solvents.

3) Oxidation of primary amine to nitro groups:

In view of the general interest among the energetic chemistry community, we examined various inexpensive oxidants for the conversion of primary amine to nitro compounds both, in solid as well as homogeneous solution phase chemistry. For this purpose, the model compound aniline and 4-nitroaniline was subjected to oxidation with clayfen and 10% $NaIO_4$ impregnated silica gel under the influence of microwave irradiation at various power levels. At 50 % power level, only 30 % conversion to nitro group takes place with sodium periodate. When the reaction is conducted under acidic conditions, such as, acetic acid starting compound is recovered as such. We have also explored $NaBO_3.4H_2O$ on solid surface but without any success. Further work in this regard is under progress using other oxidants on various other 'doped' surfaces.

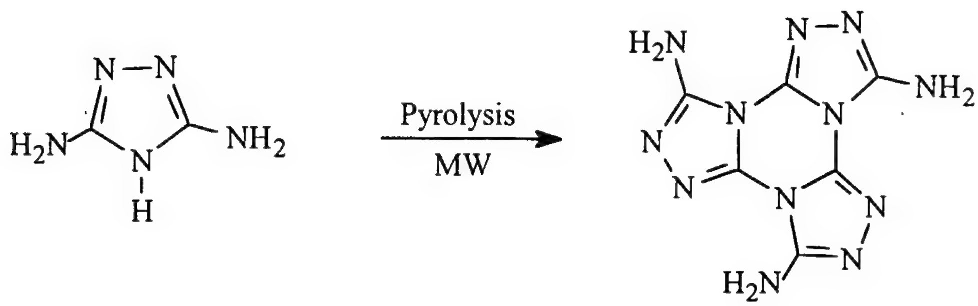


(30 % yield)

The study of the above reactions in solution phase chemistry will be more appropriate in view of the potential hazards of the exposure of these nitro compounds to microwave irradiation.

4) Microwave Thermolysis of Guanazole-Synthesis of Tris(aminotriazolo)- triazine:

The pyrolysis of the guanazole was successfully effected by thermolysis using microwaves to afford Tris(aminotriazolo)triazine (TATT) in quantitative yields. Earlier workers obtained a poor yield of the product along with the major amount of unreacted starting material. The microwave method appear to be a superior alternative as no tedious repetitive purification of the product by hot water extraction is needed as is required by the protocol described by Dr. Bill Koppes. The IR spectrum of the compound is in agreement with the IR sent by Dr. Bill Koppes of the pure product. The MW thermolysis product was sent to Dr. Bill Koppes for further analysis and comparison.



5) Hydrogenolysis of benzylic derivatives by catalytic hydrogen transfer:

The following catalytic hydrogen transfer reaction were attempted in the course of ongoing effort for the debenzylation of the hexabenzylhexaazaisowurtzitane (HBIW):

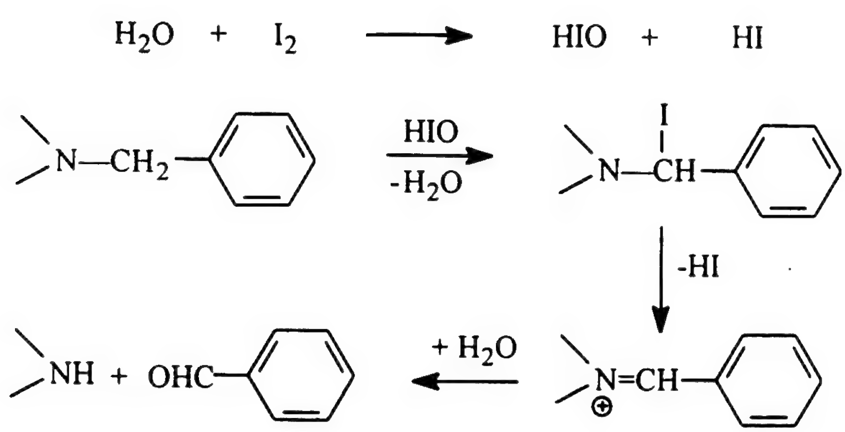
(i) The reactions of HBIW was investigated under microwave irradiation conditions using Pd/C, ammonium formate in ethylene glycol/DMF. The reason for the use of ethylene glycol and DMF is that they are very good heat transfer agents. But in ethylene glycol and DMF the substrate breaks apart yielding benzyl amine and unidentified materials.

(ii) The reaction of HBIW in the presence of ammonium formate, acetic anhydride and Pd/C was also investigated with the expectation that the simultaneous replacement of benzyl group can be achieved by the acetyl group. But in this case also the cage disintegration was observed and no intact product being formed.

(iii) Catalytic hydrogen transformation with Pd/C in presence of 1,4-cyclohexene in a mixture of absolute ethanol and THF was also attempted which resulted in the recovery of major amount of starting HBIW.

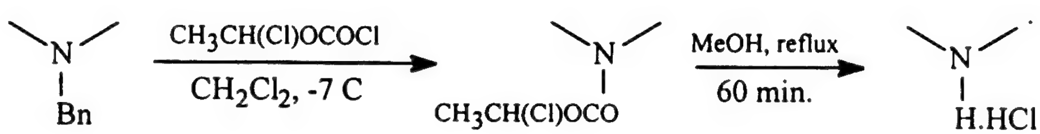
6) Debenzylation reactions for hexabenzylhexaazaisowurtzitane (HBIW):

a) Iodine on Solid Support (Alumina): Iodine reacts with water on activated surface of alumina to give HI and HIO. HIO is a potential oxidizing agent for benzylic hydrogens resulting in the formation of water molecule and C—I bond. This converts N-benzyl amine to Schiff's bases by elimination of another molecule of HI which upon hydrolysis with water generates amine (see scheme below). This property of iodine on alumina surface is exploited under a variety of conditions and using different type of solid supports and the model compounds. However, the results have not been very encouraging and the successful debenzylation is not achieved.



b) N-iodosuccinimide on Alumina: In view of the failure of iodine supported on solid supports, we explored the alternative radical reaction for achieving this transformation using N-halo succinimides, particularly N-iodosuccinimide (NIS). The later can be generated in-situ by the treatment of KI with NBS. Consequently, an attempt for debenzylation was made by NIS (NBS + KI) over alumina. The rationale for using NIS is to convert NCH_2Ar to NCHIAr by a thermal homolytic process which can lead to the cleavage of N—C bond as explained above. This approach did not work satisfactorily either.

c) Using a-chloroethyl chloroformate: More recently, we explored the debenzylation reaction with hexabenzylhexaazaisowurtzitane (HBIW) employing a-chloroethyl chloroformate [literature reference: *Synlett 195(1993)*] The reaction appears to proceed as the starting material is disappearing rather rapidly. The isolation of the ensuing amine in the form of a carbamate intermediate and its subsequent conversion to hydrochloride salt or an acetyl derivative need to be investigated in detail. Work on this transformation needs further exploration.



7) Oxidation reactions:

a) Facile oxidation of alcohols by MnO_2-Alumina

We have successfully completed the selective oxidation of alcohols to carbonyl compounds using silica-supported manganese dioxide (MnO_2) under solvent-free conditions in a process that is accelerated by microwave irradiation (Varma *et al.* Tetrahedron Letters, **38**, 7823 (1997). Among various supports examined (clay, alumina, silica), silica is found to be the best. The experimental procedure involves a simple mixing of neat alcohols with silica-supported manganese dioxide and irradiating the reaction mixtures in a microwave oven for 20-60 seconds in the absence of any solvent. This extremely rapid, manipulatively simple, inexpensive and selective protocol avoids the use of excess solvents and toxic oxidants. The same reagent with N-acetyl azetidinol, however, gives only 15 % of the oxidized product.

b) Oxidation of azitidinol with Iodoxybenzoic acid (IBX):

Oxidation of different hindered alcohols has been reported in DMSO. Our efforts to oxidize azitidinol with IBX in DMSO were not met with any success.

PROPOSED FUTURE WORK:

1) Hydrogenolysis of benzylic derivatives by catalytic hydrogen transfer:

Among others, following reactions should be investigated as a result of the discussion with Dr. Koppes during the Energetic Chemistry Workshop in Baltimore.

(i) Formic acid in methanol solution that easily removes benzyloxy carbonyl protecting groups and N-benzyl group using Pd-black as catalyst should be explored under mild conditions.

(ii) If the cage compound is prone to acidic cleavage under above conditions the reaction with Pd-charcoal in methanol or DMF using ammonium formate as hydrogen transfer agent should be considered.

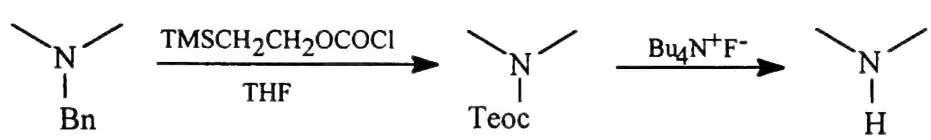
(iii) Catalytic hydrogen transfer using Pd-C in ethanol in presence of 1,4-cyclohexene should be looked into for the cleavage of N-bz and O-bz group.

(iv) The above reactions should also be investigated under microwave irradiation conditions using Pd/C, ammonium formate in ethylene glycol/DMF; ethylene glycol and DMF are very good heat transfer agents.

(v) The debenzylation with PdO in ethanol need to be explored.

(vi) The role of moisture in the debenzylation reactions using microwave irradiation need to be investigated and may be the limitation experienced with the reactions explored thus far. The influence of moist basic supports should be particularly investigated.

(vii) The N-debenzylation by Teoc-Cl (2-trimethylsilylethylchloroformate) in THF, a general method for the removal of benzyl group from nitrogen need to be studied. Additionally, inexpensive chloroformate derivatives should also be investigated.

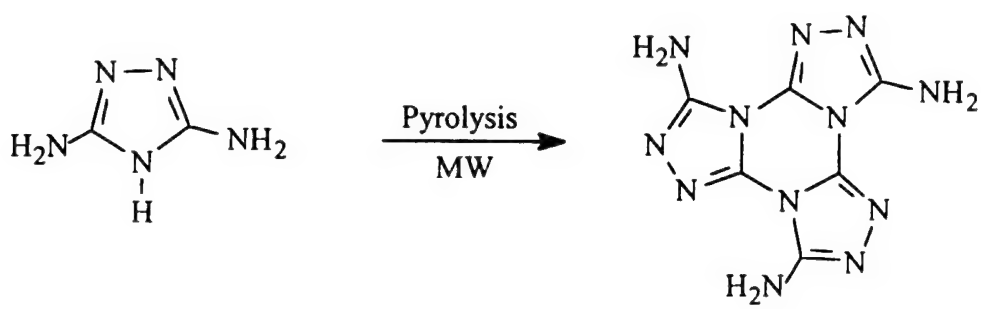


2) Oxidation reactions:

Iodoxybenzoic acid in DMSO is found to oxidize various hindered alcohols to carbonyl compound that need to be explored for the oxidation of azetidinol under these reaction conditions.

3) Microwave Thermolysis of Guanazole-Synthesis of Tris(aminotriazolo)triazine:

In consultation with Dr. Bill Koppes, a suggestion is advanced for an efficient thermolysis of guanazole to the Tris(aminotriazolo)triazine (TATT). It appears microwave heating may be ideally suited for the pyrolysis of the aminotriazole. The resulting product was sent to Dr. Koppes for analysis and comparison.



TATT

Publications and presentations of energetics work in which SERDP support was acknowledged:

ABSTRACTED PRESENTATIONS

Varma, R.S. 1997. Environmentally Benign Organic Transformations Using Microwaves Under Solvent-Free Conditions. Abstr. No. I 8, International Conference on "Green Chemistry: Challenging Perspectives," Venice, Italy, September 28-October 1.

Varma, R.S. 1997. Microwave-expedited Solventless Organic Reactions. VI International Conference on Microwave and High Frequency Heating, Fermo, Italy, 9 September.

Varma, R.S. 1997. Environmentally Benign Syntheses of Heterocyclic Compounds using Microwave Irradiation under Solventless Conditions. Abstr. No. OP-V-8, 16th International Congress of Heterocyclic Chemistry, Montana State University, Bozeman, MT, 10-15 August.

Varma, R.S., R.K. Saini, R. Dahiya, & H.M. Meshram. 1997. Solventless Oxidations with Supported Reagents using Microwaves: Novel Protocols for Organic Synthesis. pp 154-157 of Proceedings of the 32nd Microwave Power Symposium, International Microwave Power Institute, Ottawa, Canada, 14-16 July.

Varma, R.S. 1997. Microwave Induced Organic Reactions in Solventless Systems. EPA Green Chemistry and Engineering Conference, Washington, DC, 23-25 June.

Varma, R.S. 1997. Environmentally Benign Approaches to Chemical Syntheses using Microwave Irradiation under Solvent-Free Conditions, Engineering Foundation, Conference on Clean Products and processes, San Diego, California, June 2-5.

Varma, R.S, R.K. Saini, R. Dahiya, M. Varma. 1997. Environmentally Benign Approach to Chemical Syntheses using Microwave Irradiation under Solvent-free Conditions. Abstract No. ENVR 109, 213th National ACS Meeting, San Francisco, CA, 13-17 April.

Varma, R.S, R.K. Saini, R. Dahiya, M. Varma. 1997. Microwave-Assisted Reactions on Clay and Supported Reagents under Solvent-Free Conditions. Abst. No. ORGN 659, 213th National ACS Meeting, San Francisco, California, April 13-17.

Varma, R.S. 1997. Microwave-Assisted Reactions Under Solvent-Free 'Dry' Conditions. *First World Congress on Microwave Processing*, Session XIV: Chemistry IV-Solid State Synthesis and Theory. Paper No. XIV-3. 5-9, January.

Varma, R.S. & R. Dahiya. 1997. A facile solid state oxidation of alcohols by clay-supported iron (III) nitrate (Clayfen) using microwave irradiation. Texas Academy of Science. Huntsville, TX. Abstract #102 in: Program and Abstracts of Papers, 100th Annual Meeting, 6-8 March.

Varma, R.S. & R.K. Saini. 1997. Microwave-assisted synthesis of naturally occurring flavones under solvent-free conditions on solid supports. Texas Academy of Science. Huntsville, TX. Abstract #63 in: Program and Abstracts of Papers, 100th Annual Meeting, 6-8 March.

Varma, R.S. & R.K. Saini. 1997. A facile isomerization of 2¢-aminochalcone on clay: An easy route to 2-aryl- 1,2,3,4-tetrahydro-4-quinolones. Texas Academy of Science. Huntsville, TX. Abstract #103 in: Program and Abstracts of Papers, 100th Annual Meeting, 6-8 March.

Varma, R.S., S. Kumar, & H.M. Meshram. 1996. Solvent-free organic reactions using microwave irradiation: synthesis of imines, enamines and nitroalkenes. Presented to American Chemical Society 52nd Southwest Regional Meeting, abstract #143 published in Proceedings of the American Chemical Society 52nd Southwest Regional Meeting, Houston, TX., 17-19 October.

Varma, R.S., S. Kumar, & R. Dahiya. 1997. Clay catalyzed solvent-free generation of enamines and nitroalkenes using microwaces: Applications in the synthesis of heterocyclic compounds. Texas Academy of Science. Huntsville, TX. Abstract #57 in: Program and Abstracts of Papers, 100th Annual Meeting, 6-8 March.

PROFESSIONAL ARTICLES

Varma, R.S. & R. Dahiya. 1997. Microwave-assisted oxidation of alcohols under solvent-free conditions using Clayfen. *Tetrahedron Lett.*, 38:2043-2044.

Varma, R.S., R. Dahiya, & S. Kumar. 1997. Clay catalyzed synthesis of imines and enamines under solvent-free conditions using microwave irradiation. *Tetrahedron Lett.* ,38:2039-2042.

Varma, R.S., R.K. Saini, & O. Prakash. 1997. Hypervalent iodine oxidation of phenolic Schiff's bases: Synthesis of 2-arylbenzoxazoles. *Tetrahedron Lett.*, 38:2621-2622.

Varma, R.S. & R.K. Saini. 1997. Solid state dethioacetalization using Clayfen. *Tetrahedron Lett.* , 38:2623-2624.

Prakash, O., R.K. Saini, S.P. Singh, & R.S. Varma. 1997. Hypervalent iodine oxidation of *o*-aminochalcones: A novel synthesis of 3-(β-styryl)-2,1-benzisoxazoles. *Tetrahedron Lett.*, 38:3147-3150.

Varma, R.S. & R.K. Saini. 1997. Microwave-assisted reduction of carbonyl compounds in solid state using sodium borohydride supported on alumina. *Tetrahedron Lett.*, 38:4337-4338.

Varma, R.S., R. Dahiya & S. Kumar. 1997. Microwave-assisted Henry reaction: Solventless synthesis of conjugated nitroalkenes. *Tetrahedron Lett.*, 38:5131-5134.

Varma, R.S. & H.M. Meshram. 1997. Solid state deoximation with ammonium persulfate-silica gel: Regeneration of carbonyl compounds using microwaves. *Tetrahedron Lett.*, 38:5427-5428.

Varma, R.S., R.K. Saini, & H.M. Meshram. 1997. Selective oxidation of sulfides to sulfoxides or sulfones by microwave thermolysis on wet silica-supported sodium periodate. *Tetrahedron Lett.*, 38:6525-6528.

Varma, R.S. 1997. Microwave-Assisted Reactions under Solvent-Free 'Dry' Conditions. *Microwaves: Theory and Application in Material Processing IV.* American Ceramic Society 80:357-365.

Varma, R.S. & R.K. Saini. 1997. Microwave-assisted isomerization of 2'-aminochalcones on clay: An easy route to 2-aryl-1,2,3,4-tetrahydro-4-quinolones. *Synlett.* 857-858.

Varma, R.S., R. Dahiya & R.K. Saini. 1997. Iodobenzene diacetate on alumina: Oxidation of alcohols in solventless system using microwaves. *Tetrahedron Lett.*, 38:7029-7032.

Varma, R.S., R.K. Saini & R. Dahiya. 1997. Oxidation of alcohol to carbonyl using manganese dioxide/silica. *Tetrahedron Lett.* , 38:7823-7824.

Varma, R.S. & R. Dahiya. 1997 (in press). Microwave-assisted facile synthesis of imines and enamines using Envirocat EPZG^R as a catalyst. *Synlett*, 1245-1246.

Varma, R.S. & H.M. Meshram. 1997. Cleavage of semicarbazones and phenylhydrazones with ammonium persulfate/clay. *Tetrahedron Lett.*, 38:7973-7976.

Varma, R.S., R.K. Saini, & R. Dahiya. 1998 (in press). Selective oxidations using alumina supported iodobenzene diacetate under solvent-free conditions. *J. Chem. Res. (S)* . and *J. Chem. Res. (M)*

Varma, R.S., R.K. Saini, & R. Dahiya. 1997. Solid state regeneration of ketones from oximes on wet silica supported sodium periodate using microwaves. *Tetrahedron Lett.*, 38:8819-8820.

Varma, R.S. & R.K. Saini. 1998 (in press). Wet alumina supported chromium(VI) oxide: selective oxidation of alcohols in solventless system. *Tetrahedron Lett.*, 39, .

Varma, R.S. & R. Dahiya 1998 (in press). Copper(II) nitrate on clay (claycop)–hydrogen peroxide: selective and solvent-free oxidations using microwaves. *Tetrahedron Lett.*, 39:

BOOKS

Varma, R.S. 1997. Microwave-Assisted Reactions under Solvent-Free 'Dry' Conditions. *Microwaves: Theory and Application in Material Processing IV.* American Ceramic Society 80:357-365.

Final Technical Report

SERDP Project Number CS-1068
P Number 96pr06634-02

Section III
Enhancement of Image Assessment Capabilities for Natural Resource Characterization
ORNL Contract Numbers 17X-SW479C and 28X-SW479C

Dr. Patrick Van Fleet, Dr. Harry Konen, Dr. Jaimie Hebert, Dr. Wasin So, Dr. Mark Carpenter, Dr. Johnny Carroll, and Dr. Cecil Hallum

Texas Research Institute for Environmental Studies
College of Arts & Sciences
Department of Mathematics and Computer Sciences
Sam Houston State University

Dr. Virginia H. Dale & Tom L. Ashwood

Environmental Sciences Division, Oak Ridge National Laboratory

Scott A. Tweddale

U.S. Army Corps of Engineers, Construction Engineering Research Laboratories

Strategic Environmental Research and Development Program
Pollution Prevention Thrust Area

ENHANCEMENT OF IMAGE ASSESSMENT CAPABILITIES FOR NATURAL RESOURCE CHARACTERIZATION

Final Report

Virginia H. Dale and Tom L. Ashwood
Environmental Sciences Division, Oak Ridge National Laboratory

Scott A. Tweddale
U.S. Army Corps of Engineers, Construction Engineering Research Laboratories

Patrick J. Van Fleet, Michael Warnock, Mark Carpenter, Lee Graham, Cecil Hallum,
Jaimie Hebert, Harry Konen, and Wasin So
Texas Regional Institute of Environmental Studies, Sam Houston State University

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

Many DoD land managers do not take full advantage of remotely sensed data even though their use and availability is growing. Often the land managers do not even consider that these remotely sensed data may be of use to them. They typically do not have experience in applying this data to their management issues nor the tools to use the data.

We have therefore developed a web-based software system that guides land managers through the complex steps required to process remotely sensed data and assess changes over time. Assessing change is likely to be of great value to land managers who must determine effects of management practices on natural resources.

With this software system the land manager needs only a computer connected to the Internet, a web browser software package, and the images he or she wants to analyze. These images must be at an electronic address where they can be accessed by the software system. All processing is done at the central computer where the software is housed.

The software system consists of a number of modules that perform tasks such as geographic registration of the images, spatial augmentation, clustering, boundary detection, and change detection. There is also a module that allows for inclusion of videography in addition to still images. Each module is designed to lead an inexperienced user through all the important steps.

The testbed for development of this software system was Fort Stewart, an Army installation in Georgia. A workshop was conducted at Fort Stewart to demonstrate and test and early version of the software. Suggestions from the workshop were incorporated into the software system.

In the future, four important actions need to be taken. First, a case study needs to be developed through which the software system can be tested with a real-world management issue. Second, a permanent location for the software system and someone to administer it are needed. Third, refinements in the system are needed to improve its usefulness; additional improvements will be identified in the case study. Finally, the availability of the system needs to be communicated within the DoD land manager community, and training in its use is needed.

2. OVERVIEW OF CHANGE ASSESSMENT SOFTWARE

Remotely sensed data offer many opportunities for understanding and managing public and private lands. Historically, images were acquired from aerial photography; now satellite imagery provides the appropriate resolution and information for many key environmental questions. Lachowski et al. (1994) present an excellent discussion of matching the remote sensing platform to the ecological or management question being addressed.

Use and availability of remotely sensed data is growing rapidly (Croft and Kessler 1996, Johnston et al. 1997). However, many land managers and their staffs are unable to take full

advantage of this plethora of information because of time and training constraints. Thus, as Croft and Kessler (1996) note, there is a need for "smart software" to guide users through the complex steps required to process remotely sensed data and produce useful results. We have developed a web-based change assessment system that takes the first steps toward accomplishing this goal.

The world wide web provides a network over which images may be transmitted to a central processing point where user-defined processing steps are performed. This approach frees the user from the need to learn and maintain extensive image processing software. Because each image processing module operates behind a front-end program written for users not familiar with image processing, the actual processing is transparent to the user. On the other hand, users who are familiar with image processing and spatial statistics can readily configure the program to their own needs.

2.1 CHANGE ASSESSMENT

The impetus for development of this software system was a perceived need for a user-friendly means of conducting change assessments as part of the ecosystem management program at the Department of Defense. The Department of Defense (Goodman 1996), the U.S. Forest Service (Thomas 1996), and other large federal landowners are committed to implementing adaptive ecosystem management. Adaptive management requires that the results of management actions be measured and used to guide future actions (Christensen et al. 1996, De Leo and Levin 1997). Because such monitoring typically involves measuring changes, change assessment becomes a critical task for remotely sensed data processing.

Change assessment may occur at any of at least three levels: changes in raw spectral values, changes in the processed data (e.g., a land cover map), or changes in a model based on processed data and other spatial information (e.g., a habitat model for a rare species). The first level--changes in raw data--is of least interest to land managers because individual spectral values can change from hour to hour or day to day in the absence of any significant change on the ground. It is at the higher levels, after the raw data have been processed, where change assessment becomes meaningful.

Change assessment poses some interesting challenges. Errors and uncertainties in the original images propagate through the change assessment process. Determining what is a real change as opposed to apparent changes caused by errors and uncertainties is a nontrivial activity. Radiometric and atmospheric differences between image pairs in a temporal sequence is a common source of error and uncertainty in change assessment. The software system described here permits errors and uncertainties to be quantified, and the user can select the change intensity threshold (the value of difference that is assumed to represent a real change) based on the error analysis. However, this system does not contain an image calibration module, and, therefore, it is assumed that the end user is analyzing image data that have already been radiometrically and atmospherically calibrated to reduce this source of error and uncertainty.

A second challenge in change assessment is evaluating the significance of detected changes. Significance has both a statistical and an ecological component. The system described here provides the user with a means to calculate statistical significance (closely associated with the change intensity). Ecological significance is situation specific and must be assessed by the user, though this system permits the user to configure the image classification in whatever manner best captures the ecologically relevant features. For example, a land cover map could be classified into as many or as few categories as were meaningful to the user.

The testbed for development of this system was Fort Stewart, a U.S. Army installation with an adaptive ecosystem management program aimed at preserving a long-leaf pine (*Pinus palustris*) wiregrass ecosystem. In managing the long-leaf pine ecosystem, several types of changes are of interest--e.g., growth of hardwood midstory, increase in fuel loading (e.g., wiregrass), creation of (and changes in) natural and man-made openings in the forest, and the results of incidental and prescribed burns. As techniques are developed to measure individual tree size from remotely sensed images, change assessment will be valuable in monitoring growth of large trees required for red-cockaded woodpecker (*Picoides borealis*) nest sites and calculating the quality of the habitat (i.e., basal area and number of stems greater than a certain diameter). Coupled with soils information, changes in areal extent of long-leaf-pine-wiregrass communities can be used to monitor the year-to-year changes in habitat for gopher tortoises (*Gopherus polyphemus*).

In September, 1997, a workshop was held at Fort Stewart to demonstrate the system to DoD land managers and their staffs and to solicit their suggestions on changes needed to make the system more useful. Results of the workshop are described in Appendix 1. As a result of the workshop, the land managers at Fort Stewart were able to see how the system could be used to assist them in managing the system; a letter in support of the approaches from Tim Beaty, Wildlife Manager at Fort Stewart, is in Appendix 2.

2.2 APPROACH

Our approach is to provide a web site at which resource managers can perform a change assessment process that takes input from well-known GIS packages (e.g., Arc/Info, Grass) and uses new software packages based on current research results. Instead of requiring the user to be experienced with each of these software programs, we package necessary routines in a user-friendly environment, and the user provides high level control. The only hardware/software requirements are an Internet connection and a personal computer capable of running an Internet Web browser (such as Netscape or Internet Explorer).

To use the program (Fig. 1), the resource manager points the web browser to the host web site's Universal Resource Location (URL), logs in, and provides the host site with the URLs for the images to be assessed and any additional GIS data layers. The program then retrieves the data to the host machine where basic data conversion, image alignment, clipping, and masking tasks are performed. The resource manager also configures some parameters necessary to preprocess the data (default values are available). After the user submits the URLs and instructions for preprocessing to the host machine, he is sent an electronic mail (e-mail) message with a URL he can consult to determine the status of his job. Typical preprocessing can take 15 hours for large data sets (150 MB images). The user URL contains time estimates, other information, and an abort button should the user wish to stop the process. Once the preprocessing is complete, the user is notified via e-mail and then the user can return to the web site to perform tasks such as image classification, boundary detection, and change detection. The user can view various images, overlays of images, videos of change assessment and, if available, videography.

2.3 MODULES

The software system is designed to perform change assessment and other related image analysis tasks using seven modules (Fig. 2). Image registration (including clipping) and spatial augmentation are required to prepare the data for analysis. Clustering, bootstrapping, and boundary detection are modules that perform initial analysis of the data. The actual change assessment is done in the change detection module. The output module controls the manner in which data are presented to the user. A user-friendly interface allows the user to either invoke an automated version of a module, or, if desired, control various parameters needed by the module. A description of each module is provided below.

2.3.1 Image Registration

Before change detection can be accomplished, the two images must be registered to each other. Alignment of the two images is critical in order to ensure that changes detected between the two images are not artifacts of positional errors. The registration module assumes that one image (image A) is the base image. The second image (image B) is then aligned with image A.

The first step in image registration is to identify a sufficient number of control points from each image and match them. A control point represents a feature whose geographical location does not change between the two images (e.g., a road intersection or the corner of a building). A mathematical concept called wavelets (Strang 1989) is used in this routine to automatically select these points. However, the software also provides the user with the ability to manually select control points in each image. The next step is to estimate the geometric deformation of the control points between the two images. The routine then employs a resampling technique to generate a new (registered) version of the image B. The module can run in a default mode, or if desired, the user may specify the wavelet decomposition, the minimum number of control points allowed, or the resampling method.

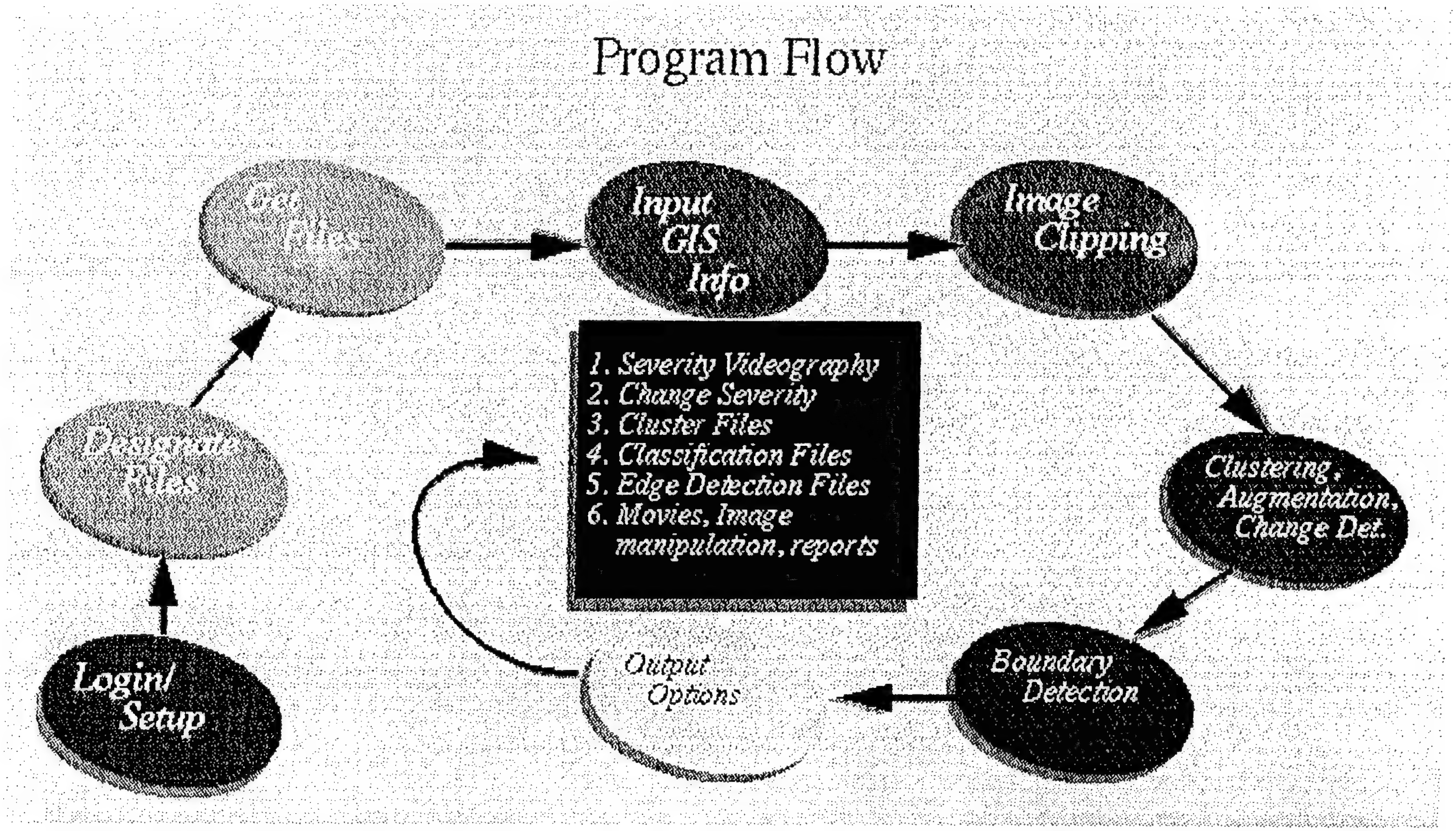


Fig. 2. Functional Flow of Software System

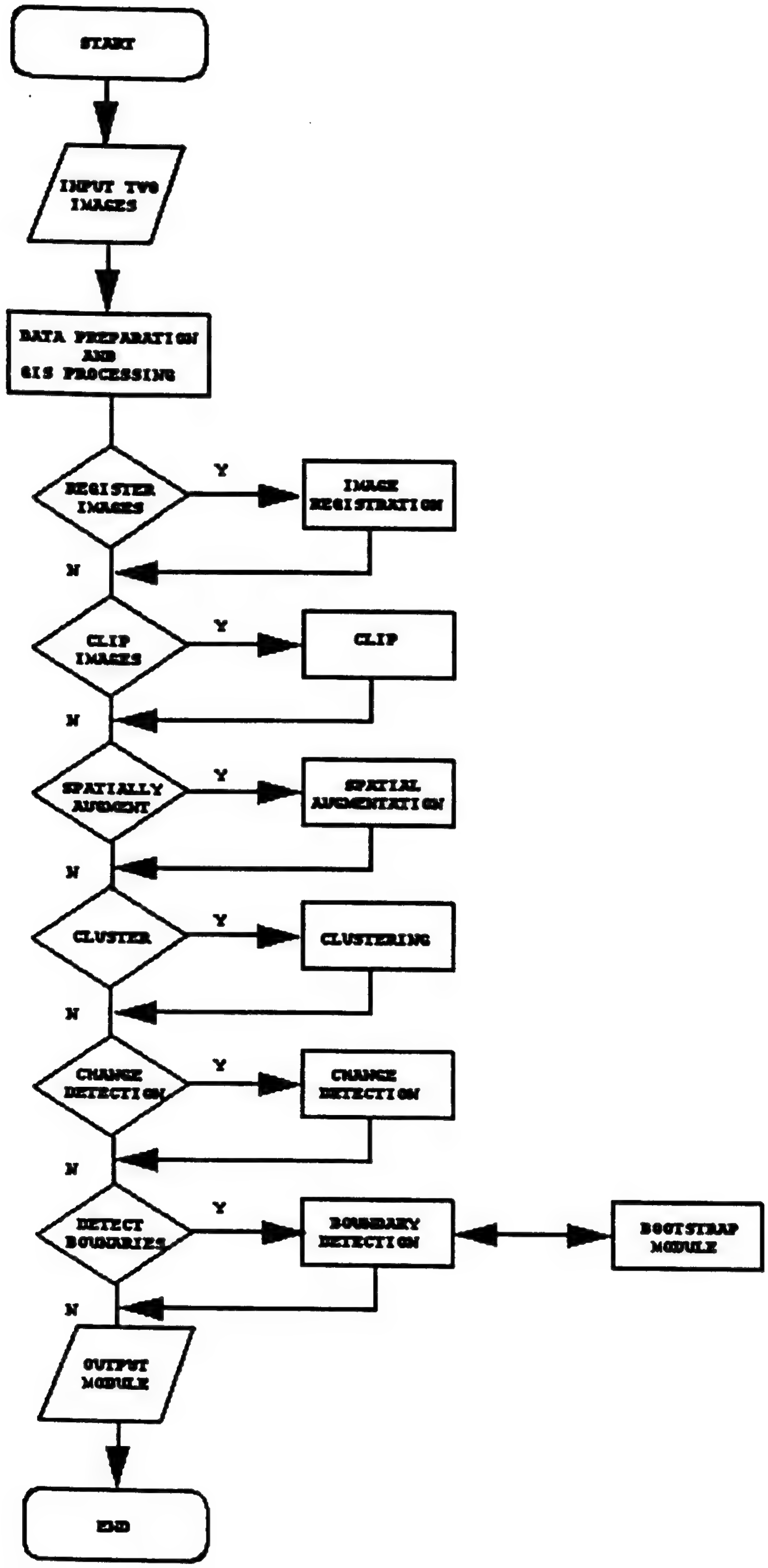


Fig. 2. Software System Schematic Flow Chart

2.3.2 Spatial Augmentation

Spatial augmentation describes the correlation between neighboring pixels. For example, consider a satellite image that consists of 7 bands of data. Each pixel in the image has 7 values assigned to it. In spatial augmentation we create 7 additional bands of information. The first band of original data can be configured as a rectangular table of values corresponding to the number of rows and columns in the image. For each entry in the table (i.e., for each pixel in the image), we average the values immediately surrounding the entry. This new number is stored as the corresponding value for the new band of augmented data. This procedure is repeated for every entry and then for every band. The augmented data bands can be used as any other multivariate data set, but the analysis includes information regarding the spatial relationship among pixels.

2.3.3 Clustering

Clustering is a form of information classification whereby pixels with similar properties are grouped together. The clustering module allows the user to select from a wide variety of clustering techniques as well as to select the number of clusters (or classes). The routine also chooses the optimal number of clusters for a given scene. At present the module is only designed to allow for unsupervised classification (where the program chooses the categories), but supervised classification (where the user chooses the categories) can be added.

The module can be run in a default mode or the user can control the amount of preprocessing required or the number of clusters. The routine can also generate a dendogram that can be used to assist the user in selecting the optimal number of clusters.

2.3.4 Estimation via Bootstrapping

Bootstrapping is a technique for estimating statistics such as mean, variance, or percentiles. Unlike other statistical techniques, bootstrapping makes no assumption about the distribution of the data and is therefore quite useful in image analysis, where the properties of the distribution are not known. To perform bootstrapping, the data set is randomly sampled with replacement and the desired statistic is computed for this sample. This process is repeated a large number of times, and the average of these values is returned as an estimate of the desired statistic.

The bootstrapping routine provides estimates that are used for the change detection routine and the boundary detection routine. This module is transparent to the user.

2.3.5 Boundary Detection

This module searches for edges in a data set. The program allows the user to input an image file and then choose among different options in the detection process. The module can be used on a remotely sensed data set or on output from the change detection module to find edges of change. Wavelets are used to detect boundaries. A blur of the original image is produced, and the detail

lost in the horizontal, vertical, and diagonal directions between the blur and the original are recorded. The pixels forming boundaries are determined by applying a thresholding procedure to the directional differences.

The module may be run in default mode or the user can control options such as wavelet type and viewing options. Different wavelet types are provided to assist the user in better modeling the data.

2.3.6 Change Detection

The change detector is used to ascertain temporal changes between two images of the same scene. The change detector quantifies the changes, so they can be ranked and/or grouped by the user. Through a multivariate statistical process, a numerical value indicating the severity of change between the two points in time is assigned to each pixel. For viewing purposes these values are converted into scene images, one image for each of level of change severity selected by the user. In these files, pixels that have not changed at the selected severity level are "blacked out." The user also has the option of creating a video of different severity level images to better understand and assess change that has occurred.

2.3.7 Videography

The output module has the capability to integrate user-supplied video imagery with the other modules. If the user has video footage of the same area covered by the images being assessed, that footage can be sequenced with the images to provide a method for further evaluating the changes or for determining what the various classes represent on the ground. The advantage of video over still pictures is that flight lines can cover a range of conditions, and subsequently the user can look at many contrasting conditions before focusing on a few for detailed analysis..

3. BENEFITS OF APPROACH

Remote sensing techniques for detecting and assessing change are cost effective compared to traditional methods. Individual modules employ state-of-the-art research techniques. The program is designed to reside at one location, thus alleviating natural resource managers of the task of installing and upgrading software. Hardware/software requirements for the end user consist of a PC with an Internet connection and a World Wide Web browser. The interface is designed so that it is user-friendly for natural resource managers and does not require a mathematics/statistics background.

4. SUGGESTED NEXT STEPS IN DEVELOPMENT OF THE SOFTWARE FOR CHANGE ASSESSMENT

Four major steps remain before the software described here can be widely used. First, the system needs to be applied to a real land management situation so that a case study of its use can be developed. This case study is important to test the approach and identify any areas where the system is not readily useable by land managers. Moreover, the case study would provide a powerful demonstration of the system's capabilities.

The second main step required is to identify and fund a permanent repository for the software and a system administrator who can do software maintenance and provide minimal technical support to users. Requirements for the server include:

- an Internet connection
- a CPU that is a MIPS 5000 or better
- runs at 200 MHz or better
- at least 128 MB RAM
- at least 8 GB hard disk
- httpd server software

The system administrator should plan to spend 5% – 10% of their time on serving as web master, handling queries that arise, and maintaining backups. Start up time may be a bit more.

Third, some work remains to make the software itself more user-friendly. Specifically, additional on-screen help documentation is needed in a format that can be readily accessed and understood by users not familiar with change detection or remote sensing jargon. Also, a tutorial would be helpful. Programming changes to eliminate the need for access to other software packages (e.g., SAS) are being implemented.

The final step is to actively communicate the availability of this software among military and DOE land managers. This communication should include not only making land managers aware of the software and its advantages but also training them to use it.

5. PRODUCTS: PAPERS, POSTERS, PRESENTATIONS, AND MEETINGS ATTENDED

Bonnie Burgan presented "Wavelet-Based Boundary Detection" and at the Texas Academy of Science in Huntsville, Texas on March 7, 1997, and at the Conference on Applied Mathematics (CAM*97) in Edmond, Oklahoma on February 21, 1997. Both of these presentations won best undergraduate paper.

A paper entitled "Wavelet-Based Boundary Detection" is in preparation by Bonnie Burgan and Pat Van Fleet.

Cheryl Button presented "Unsupervised Classification of Remotely Sensed Images with Spatially Augmented Data" at the Conference of Applied Mathematics (CAM*97) on February 21, 1997, in Edmond, Oklahoma.

Cheryl Button and Jaimie Hebert wrote a paper entitled "Unsupervised Classification of Remotely Sensed Images with Spatially Augmented Data." It was submitted to the Proceedings of the Conference of Applied Mathematics (CAM*97).

Mark Carpenter, Jamie Hebert, and Ren Quan presented "Using Cluster and Classification Analysis to Detect the Impact of Military Training on the Environment: A Case Study" for the American Statistical Association, Environmental Statistics Section in Chicago in August, 1996.

Mark Carpenter presented "Reverse Order Canonical Correlation Applied to Remotely Sensed Imagery" at the American Statistical Association Joint Statistical Meeting in Anaheim, California in August, 1997.

Mark Carpenter submitted a paper entitled "Statistical Descriptions of Digitized Satellite Imagery" to the *Journal of the American Statistical Association*, Case Study and Application Section.

Paul Cornils presented "Optimal Cluster Number Identification in Unsupervised Classification of Satellite Imagery" at the American Statistical Association Joint Statistical Meeting in Anaheim, California in August, 1997.

Cecil Hallum presented "Alternative Weighted Distance Functions in Classification Analysis" at the American Statistical Association Joint Statistical Meeting in Anaheim, California in August, 1997.

Paul Plank presented "Using Cluster and Classification Analyses to Detect the Impact of Military Training on the Environment" at the Joint American Statistical Association Meeting in Chicago in August, 1996.

6. LITERATURE CITED

Christensen, N. L., A. M. Bartuska, J. H. Brown, S. Carpenter, C. D'Antonio, R. Frances, J. F. Franklin, J. A. MacMahon, R. F. Noss, D. J. Parsons, C. H. Peterson, M. G. Turner, and R. G. Woodmansee. 1996. The report of the Ecological Society of America committee on the scientific basis for ecosystem management.. Ecological Applications 6(3):665-691.

Croft, F. and B. Kessler. 1996. Remote sensing, image processing, and GIS: Trends and forecasts. Journal of Forestry 94(6):31-35.

De Leo, G. A., and S. Levin. 1997. The multifaceted aspects of ecosystem integrity. Conservation Ecology [on-line]1(1): 3. Available from the Internet. URL: http://www.consecol.org/vol1/iss1/art3

Goodman, S. W. 1996. Ecosystem management at the Department of Defense. Ecological Applications 6(3):706-707.

Johnston, J. J., D. R. Weigel, and J. C. Randolph. 1997. Satellite remote sensing: An inexpensive tool for pine plantation management. Journal of Forestry 95(6):16-20.

Lachowski, H. M., T. Wirth, P. Maus, and P. Avers. 1994. Remote sensing and GIS: Their role in ecosystem management. Journal of Forestry 92(8):39-40.

Thomas, J. W. 1996. Forest Service perspective on ecosystem management. . Ecological Applications 6(3):703-705.

Strang, G. 1989. Wavelets and Dilation Equations: A Brief Introduction. Society for Industrial and Applied Mathematics Review. 31(4):614-627.

APPENDIX 1 WORKSHOP REPORT

A workshop was held in early September, 1997, at Fort Stewart, Georgia, to demonstrate new internet-based software designed to allow natural resource managers at military installations the ability to perform change assessment. Many monitoring activities involve measuring changes in vegetation, habitat, training impacts, or other natural or cultural resources. These changes can be monitored by remote sensing (either from satellites, aerial photography, or videos of an area). Change assessment techniques provide a means to compare scenes at different times and to quantify the differences that occur between the two scenes. The web-based software is designed to facilitate such assessments and is primarily targeted toward resource managers.

This software provides powerful change assessment capabilities in a format that can be used by individuals with little image processing or GIS training. A further advantage is that the hardware and software reside at a central location. Therefore in order to acquire access to the software, all that a user needs is an internet connection and a web browser.

The twenty-five attendees at the workshop were led through the software. They were shown how to enter the web site, preprocess the data, and run the change assessment modules. Some discussion occurred regarding the ways in which the results could be interpreted.

The workshop participants had many suggestions for cosmetic improvements to the software that will clarify instructions to the user. Also, some discussion occurred regarding future steps in the development of the program. All in all, the workshop participants were enthusiastic about the product. One participant summarized the workshop by saying the software package would not necessarily make their job any easier (meaning that the monitoring would be performed differently than had been done previously), but it was clear that the work would be done *better* with this newly created software.

The staff at Fort Stewart was so interested in the software that they are exploring the possibility of obtaining the software on the base. The software could provide a means for sharing data files between different offices on the base (e.g., Forestry, Fish and Wildlife, ITAM).

The software will be useful to the Fort Stewart staff no matter where it is located. The staff discussed four ways that they envision using this software:

1. To determine the coverage of burns from year-to-year to assess the effectiveness of the burn program.

2. To monitor wiregrass re-establishment--currently very labor intensive using field efforts.

3. To monitor the status of the hardwood understory within the pine forest.

4. To use as a tool for ITAM to monitor ground cover disturbances and to assess which areas are deteriorating and which ones are recovering.

In summary, the workshop was very beneficial for the resource managers at Fort Stewart; they saw the possibilities of using a web-based computer program to assist them in doing a better job of monitoring and managing the resources at the base. The staff from Fort Stewart donated almost a full day to participate in the workshop and provide suggestions and uses for the software. The developers of the software package were able to get direct feedback on the appearance and workings of the software modules. During the reminder of the funding period, improvements will be made in the software that should address many of the issues.

APPENDIX 2 LETTER OF SUPPORT FROM TIM BEATY, FORT STEWART

DEPARTMENT OF THE ARMY
HEADQUARTERS, 3D INFANTRY DIVISION (MECHANIZED) AND FORT STEWART

REPLY TO
ATTENTION OF

8 OCT 1997

Fish and Wildlife Branch

Dr. Virginia H. Dale
Environmental Sciences Division
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6036

Dear Virginia,

Thank you for the opportunity to participate in the demonstration of the Web Image Analysis and Remote Sensing (WIARS) software. I think the project has real potential, especially for users who may not have access to GIS and Remote Sensing software at their home stations. By providing access to both the analytical software and a catalog of available images, the system will make image analysis tools available to a whole host of new users. At Fort Stewart, the system could be used for tracking changes at the landscape level in response to land management actions and/or land use activities. I understand that your team is already working to incorporate some of the recommendations made at the demonstration workshop to make the system more effective and user friendly. We look forward to seeing the final product. We are always interested in new tools to better manage threatened and endangered species and other natural resources.

Thanks again for making Fort Stewart a part of your project. If you have questions about any of the comments provided at the demonstration, or if additional information is needed, please let me know.

Sincerely,

Timothy A. Beaty

Tim Beaty
Supv., Wildlife Biologist

APPENDIX 3 ABSTRACTS OF PAPERS AND POSTERS

SAM HOUSTON STATE UNIVERSITY 1879

Mathematical and Information Sciences

Mathematics – Statistics – Computer Science

1901 Avenue J
Rm 420 Lee Drain Bldg

Huntsville, Texas
P.O. Box 2206 77341–2206

(409)–294–1563
FAX(409)–294–1882

"WAVELET-BASED BOUNDARY DETECTION"

Bonnie Burgan
Department of Mathematical and Information Sciences
Sam Houston State University
Huntsville, TX

Abstract. One of the many applications of wavelets is boundary detection. Given a digitized image, a basic boundary detection method is as follows: (1) preprocess the image, (2) apply an appropriate linear transformation in order to depict directional differences, and (3) subject the result to a decision rule to determine boundaries. In an effort to locate boundaries more precisely, we have made improvements on the above algorithm.

Typical preprocessing involves a convolution of the image with a smoothing function. We suggest a method involving an adaptive characteristic function. From a mathematical point of view, it is advantageous to use wavelets because they possess good local approximation properties. Computationally the wavelets are a practical choice due to the sparse nature of the transformation. As an alternative to hard thresholding, we employ bootstrapping. Bootstrapping is an iterative method that provides a decision rule for determining boundaries, but makes no assumption on the underlying distribution. We have written a computer program to perform boundary detection and conclude the talk with examples that illustrate our results.

A Member of The Texas State University System
Sam Houston State University Is An Equal Opportunity/Affirmative Action Institution

Unsupervised Classification of Remotely Sensed Images With Spatially Augmented Data

by

Cheryl Button
Jaimie Hebert
Dept. Of Mathematics and Informational Sciences
Sam Houston State University

ABSTRACT: One of the objectives in processing remotely sensed images is to classify individual observations into relatively homogeneous groups. In some instances, the classification scheme is based on biological attributes of the observations and undertaken using scientifically developed vegetative indices. Other researchers have used discriminant analysis, when ground truthed data is available for training, and clustering methods in the absence of ground truthed data. These techniques are statistical procedures that take advantage of the multivariate information contained in the data. Several papers have considered the merits of these procedures in image processing including the use of k-means clustering to classify observations when ground data is not available.

Relatively few papers address the use of spatial statistical methods in conjunction with these procedures. An exception is Switzer (1980) who proposes a simple approach to incorporate spatial information into an unsupervised classification scheme. In the present manuscript, we present a case study that compares the results of using k-means clustering to classify observation from a LANDSAT 5 remotely sensed image before and after implementing Switzer's technique. A discussion of pre-augmentation clusters is presented and known land-types are identified. The effect of spatial augmentation is depicted graphically by producing images of re-classified observations.

Estimating Minimum and Maximum Location Parameters for Two Gamma-Exponential Scale Mixtures in Pitman Measure

Quan Ren, Jaimie L. Hebert, and Mark Carpenter, Sam Houston State University
Jaimie L. Hebert, Department of Mathematical and Information Sciences, SHSU, Huntsville, TX 77341

Keywords: Pitman's closeness, mean squared error, maximum likelihood estimator.

1. Introduction

Suppose we have two components with lifetime X_1 and X_2 that are distributed as two-parameter exponentials with different location parameters. If these components are conditionally independent with random hazard rate Λ, then the conditional distribution of lifetime of each component denoted by $f_i(x_i|\lambda)$ for $i=1,2$ is

$$f_i(x_i|\lambda)=\lambda\exp[-\lambda(x_i-r_i)],\ r_i\le x_i<\infty. \quad (1)$$

In the present manuscript, we assume that the hazard rate, Λ, has a gamma distribution $dG(\lambda)=\Gamma(\alpha)^{-1}\beta^{\alpha}\lambda^{\alpha-1}e^{-\lambda\beta}$. Our objective is to develop estimators of the extrema $\theta_1=\min(r_1,r_2)$, $\theta_2=\max(r_1,r_2)$ and compare these estimators to MLE's in terms of Pitman closeness.

Let $X_{11},\ldots,X_{1n}$ and $X_{21},\ldots,X_{2n}$ be conditionally independent random samples from a population having distribution (1). For $I=1,2$ respectively, let

$$X_{(1)}=\min_{1\le i\le n}\{X_{1i}\},$$

$$X_{(2)}=\min_{1\le i\le n}\{X_{2i}\},$$

$$Z_1=\min\{X_{(1)},X_{(2)}\},$$

and $$Z_2=\max\{X_{(1)},X_{(2)}\}.$$

Much work has been done on the development of estimators for θ_1 and θ_2, see Carpenter and Hebert (1996). Most of these estimators are based on the statistics $X_{(1)}$, $X_{(2)}$, Z_1, and Z_2. In their work, Carpenter and Hebert (1994) show that (Z_1,Z_2) is the induced MLE of (θ_1,θ_2) and they also show that the estimator

$$\left(Z_1-\frac{\beta}{n(\alpha-1)},Z_2-\frac{\beta}{n(\alpha-1)}\right) \quad (2)$$

dominates (Z_1,Z_2) in terms of absolute bias and MSE. In this manuscript, we compare the estimator (2) to the MLE (Z_1,Z_2) and , in a more general case, the estimator (Z_1-d,Z_2-d) to (Z_1,Z_2) in terms of Pitman's closeness.

2. Distributional Results

Carpenter, Pal, and Kushary (1992) show that the joint distribution of (Z_1,Z_2) is given by

$$g(z_1,z_2)=(\lambda n)^2\exp[-\lambda n(s(z_1,z_2))]$$

when $\theta_1\le z_1\le\theta_2\le z_2$ and

$$g(z_1,z_2)=2(\lambda n)^2\exp[-\lambda n(s(z_1,z_2))]$$

when $\theta_1\le\theta_2\le z_1\le z_2$, where

$$s(z_1,z_2)=z_1+z_2-\theta_1-\theta_2.$$

The following result provides a closed form for the joint density of (Z_1,Z_2) for the gamma-exponential mixture.

Lemma 2.1. The unconditional joint distribution of (Z_1,Z_2) for the gamma exponential mixture is

$$g(z_1,z_2)=\frac{n^2\alpha\beta^{\alpha}(\alpha+1)}{[n(s(z_1,z_2)+\beta/n)]^{\alpha+2}}$$

when $\theta_1\le z_1\le\theta_2\le z_2$ and

$$g(z_1,z_2)=\frac{2n^2\alpha\beta^{\alpha}(\alpha+1)}{[n(s(z_1,z_2)+\beta/n)]^{\alpha+2}}$$

when $\theta_1\le\theta_2\le z_1\le z_2$.

Proof. For $\theta_1\le z_1\le\theta_2\le z_2$, we have

$$g(z_1,z_2)=\int_0^{\infty}g(z_1,z_2|\lambda)\,dG(\lambda)$$

$$=\int_0^{\infty}\frac{\beta^{\alpha}}{\Gamma(\alpha)}\lambda^{\alpha-1}e^{-\lambda\beta}(\lambda n)^2\exp[-\lambda ns(z_1,z_2)]\,d\lambda$$

$$=\frac{n^2\beta^{\alpha}}{\Gamma(\alpha)}\int_0^{\infty}\lambda^{\alpha+1}\exp[-\lambda n(s(z_1,z_2)+\beta/n)]\,d\lambda$$

$$= \frac{2n^2\alpha\beta^\alpha(\alpha+1)}{\left[n\left(s(z_1,z_2)+\beta/n\right)\right]^{\alpha+2}}.$$

Similarly, for $\theta_1 \le \theta_2 \le z_1 \le z_2$, we have

$$g(z_1,z_2) = \int_0^\infty \frac{2\beta^\alpha}{\Gamma(\alpha)} \lambda^{\alpha-1} e^{-\lambda\beta} (\lambda n)^2 \exp\left[-\lambda n s(z_1,z_2)\right] d\lambda$$
$$= \frac{2n^2\alpha\beta^\alpha(\alpha+1)}{\left[n\left(z_1+z_2-\theta_1-\theta_2+\beta/n\right)\right]^{\alpha+2}}.$$

3. Pitman Closeness

Let $\hat{\theta}_1$ and $\hat{\theta}_2$ be two estimators of a parameter θ. Pitman (1937) proposed a measure of relative closeness to θ for comparing two estimators.

Definition 3.1. If $\hat{\theta}_1$ and $\hat{\theta}_2$ are two estimators of a parameter θ and

$$P_\theta\left(\left|\hat{\theta}_1-\theta\right| < \left|\hat{\theta}_2-\theta\right|\right) \le P_\theta\left(\left|\hat{\theta}_1-\theta\right| > \left|\hat{\theta}_2-\theta\right|\right)$$

for all θ, then the estimator $\hat{\theta}_1$ is *Pitman Closer* to θ than $\hat{\theta}_2$.

In the remainder of this section, we compare several estimators using this definition of closeness.

Proposition 3.1. Let $\hat{\theta}_1$ and $\hat{\theta}_2$ be the estimators defined in (2). If $\alpha > 2$ and $\beta > 0$, then

$$\frac{\beta^\alpha}{n^\alpha(2C+\beta/n)^\alpha} \le P_{\theta_1}\left(\left|\hat{\theta}_1-\theta_1\right| < \left|Z_1-\theta_1\right|\right)$$
$$\frac{\beta^\alpha}{n^\alpha(C+\beta/n)^\alpha} \ge P_{\theta_1}\left(\left|\hat{\theta}_1-\theta_1\right| < \left|Z_1-\theta_1\right|\right),$$

and

$$\frac{\beta^\alpha}{n^\alpha\left(C+\beta/n\right)^\alpha} \le P_{\theta_2}\left(\left|\hat{\theta}_2-\theta\right| < \left|Z_2-\theta\right|\right),$$

where $C = \dfrac{\beta}{2n(\alpha-1)}$.

Proof: Note that

$\hat{\theta}_i = Z_i - \dfrac{\beta}{n(\alpha-1)} = Z_i - 2C$, for $i = 1,2$. Thus,

$$P_{\theta_1}\left(\left|\hat{\theta}_1-\theta_1\right| < \left|Z_1-\theta_1\right|\right) = P_{\theta_1}\left(\left|Z_1-2C-\theta_1\right| < \left|Z_1-\theta_1\right|\right)$$
$$= P_{\theta_1}\left(\left|Z_1-2C-\theta_1\right|^2 < \left|Z_1-\theta_1\right|^2\right)$$
$$= P_{\theta_1}\left(C+\theta_1 < Z_1\right).$$

Now, for $\theta_2 \le C+\theta_1$,

$$P_{\theta_1}(C+\theta_1 < Z_1) = \int_{C+\theta_1}^\infty dz_1 \int_{z_1}^\infty \frac{2n^2\alpha\beta^\alpha(\alpha+1)}{\left[n\left(s(z_1,z_2)+\beta/n\right)\right]^{\alpha+2}} dz_2$$
$$= \frac{\beta^\alpha}{\left[n\left(2C-\theta_1-\theta_2+\beta/n\right)\right]^\alpha}$$
$$\le \frac{\beta^\alpha}{n^\alpha\left(C+\beta/n\right)^\alpha}.$$

For $\theta_2 > C+\theta_1$,

$$P_{\theta_1}(C+\theta_1 < Z_1) = \int_{C+\theta_1}^{\theta_2} dz_1 \int_{\theta_2}^\infty \frac{n^2\alpha\beta^\alpha(\alpha+1)}{\left[n\left(s(z_1,z_2)+\beta/n\right)\right]^{\alpha+2}} dz_2$$
$$+ \int_{\theta_2}^\infty dz_1 \int_{z_1}^\infty \frac{2n^2\alpha\beta^\alpha(\alpha+1)}{\left[n\left(s(z_1,z_2)+\beta/n\right)\right]^{\alpha+2}} dz_2$$
$$= \frac{\beta^\alpha}{n^\alpha}\left[\frac{1}{(C+\beta/n)^\alpha} - \frac{1}{(\theta_2-\theta_1+\beta/n)^\alpha}\right]$$
$$+ \frac{\beta^\alpha}{n^\alpha(\theta_2-\theta_1+\beta/n)^\alpha}$$
$$= \frac{\beta^\alpha}{n^\alpha(C+\beta/n)^\alpha}$$
$$\ge \frac{\beta^\alpha}{n^\alpha(2C+\beta/n)^\alpha}.$$

Similarly, when $\alpha > 2$ and $\beta > 0$, we have

$$P_{\theta_1}\left(\left|\hat{\theta}_2-\theta_2\right| < \left|Z_2-\theta_2\right|\right) = P_{\theta_1}\left(C+\theta_2 < Z_2\right)$$
$$\ge \frac{\beta^\alpha}{n^\alpha(C+\beta/n)^\alpha}$$
$$\ge \frac{\beta^\alpha}{n^\alpha(2C+\beta/n)^\alpha}.$$

The bounds that are provided in the proposition are dependent upon the parameters in the mixing distribution. The following lemma provides bounds that are independent of the mixing parameters.

Lemma 3.1. Let $\hat{\theta}_1$ and $\hat{\theta}_2$ be the estimators defined in (1.2). If $\alpha > 2$ and $\beta > 0$, then

$$\frac{1}{4} \le P_{\theta_1}\left(\left|\hat{\theta}_1 - \theta_1\right| < \left|Z_1 - \theta_1\right|\right) \le e^{-1/2}$$

and

$$\frac{1}{4} \le P_{\theta_1}\left(\left|\hat{\theta}_2 - \theta\right| < \left|Z_2 - \theta\right|\right).$$

Proof. Since $C = \frac{\beta}{2n(\alpha - 1)}$,

$$\frac{\beta^\alpha}{n^\alpha (C + \beta/n)^\alpha} = \left(1 - \frac{1}{2\alpha - 1}\right)^\alpha$$

$$= \sqrt{\left(1 - \frac{1}{2\alpha - 1}\right)^{2\alpha - 1}\left(1 - \frac{1}{2\alpha - 1}\right)}$$

$$< \sqrt{\left(1 - \frac{1}{2\alpha - 1}\right)^{2\alpha - 1}}.$$

Now consider the function $\varphi(t) = \ln(1 - t^{-1})^t$ with $t > 0$. Direct calculation yields $\varphi'(t) = \ln\left(\frac{t-1}{t}\right) + \frac{t}{t-1} - 1$. Now define the function $\Psi(u) = \ln u + u^{-1} - 1$ with $0 < u \le 1$. It follows that $\Psi'(u) = u^{-1} - u^{-2} < 0$. Thus, $\Psi(u)$ is strictly decreasing on $(0,1]$ and $\Psi(u) > \Psi(0) = 0$ for all $u \in (0,1]$. Thus, $\varphi(t) = \ln(1 - t^{-1})^t$ is increasing for $t > 1$ and it follows that $(1 - t^{-1})^t$ is increasing over $(1, \infty)$. Also, since $\lim_{t \to \infty}(1 - t^{-1})^t = e^{-1}$, it follows that $(1 - t^{-1})^t \le e^{-1}$ for all $t > 1$. Letting $t = 2\alpha - 1$ it follows that

$$\frac{\beta^\alpha}{n^\alpha (C + \beta/n)^\alpha} < \sqrt{\left(1 - \frac{1}{2\alpha - 1}\right)^{2\alpha - 1}} < e^{-1/2}.$$

The remaining inequalities follow from the fact that when $\alpha > 2$,

$$\frac{\beta^\alpha}{n^\alpha (2C + \beta/n)^\alpha} = \left(1 - \frac{1}{\alpha}\right)^\alpha > \left(1 - \frac{1}{2}\right)^2 = \frac{1}{4}.$$

Theorem 3.1. For $\alpha \ge 3$ and $\beta > 0$, $\hat{\theta}_2$ is Pitman closer than Z_2 to θ_2.

Proof. Since the probability

$$P_{\theta_2}\left(\left|\hat{\theta}_2 - \theta_2\right| < \left|Z_2 - \theta_2\right|\right) \ge \frac{\beta^\alpha}{n^\alpha (C + \beta/n)^\alpha}$$

$$= \left(1 - \frac{1}{2\alpha - 1}\right)^\alpha$$

is increasing in α and $\alpha \ge 3$, it follows that

$$P_{\theta_2}\left(\left|\hat{\theta}_2 - \theta_2\right| < \left|Z_2 - \theta_2\right|\right) \ge \left(1 - \frac{1}{2\alpha - 1}\right)^\alpha$$

$$\ge \left(1 - \frac{1}{2(3) - 1}\right)^3$$

$$= \frac{64}{125} > \frac{1}{2}.$$

Theorem 3.2. For $\alpha \ge 3$ and $\beta > 0$, $\hat{\theta}_1$ is *not* Pitman closer than Z_1 to θ_1 and Z_1 is *not* Pitman closer than $\hat{\theta}_1$ to θ_1.

Proof. Consider the case $\theta_2 = \theta_1$. Since $C > 0$, we have $\theta_2 \le C + \theta_1$ and it follows that

$$P_{\theta_1}\left(\left|\hat{\theta}_1 - \theta_1\right| < \left|Z_1 - \theta_1\right|\right) = \frac{\beta^\alpha}{\left[n(2C - \theta_1 - \theta_2 + \beta/n)\right]^\alpha}$$

$$= \frac{\beta^\alpha}{n^\alpha (2C + \beta/n)^\alpha}$$

$$= \left(1 - \frac{1}{\alpha}\right)^\alpha$$

$$< \frac{1}{2}.$$

Thus, there is at least one situation ($\theta_2 = \theta_1$) where $\hat{\theta}_1$ is not Pitman closer than Z_1 to θ_1. To see that and Z_1 is not Pitman closer than $\hat{\theta}_1$ to θ_1, we consider the case $\theta_2 > C + \theta_1$. In this case,

$$P_{\theta_1}\left(\left|\hat{\theta}_1-\theta_1\right|<\left|Z_1-\theta_1\right|\right)=\frac{\beta^{\alpha}}{\left[n(C+\beta/n)\right]^{\alpha}}$$
$$=\left(1-\frac{1}{2\alpha-1}\right)^{\alpha}$$
$$>\frac{1}{2},$$

for all $\alpha \geq 3$.

In the following results, we consider the general estimator of the form $Z_i - d$.

Theorem 3.3. For $\alpha > 2$, $\beta > 0$, and $0 < k \leq 1$, the estimator $\hat{\theta}_1^* = Z_1 - d^*$ with $d^* = k\beta\left(2^{1/\alpha}-1\right)/n$ is Pitman closer than Z_1 to θ_1.

Proof. Let $C_1 = d^*/2$. We have that

$$P_{\theta_1}\left(\left|Z_1-d^*-\theta_1\right|<\left|Z_1-\theta_1\right|\right)=P_{\theta_1}\left[\left(d^*\right)^2<2d^*\left(Z_1-\theta_1\right)\right]$$
$$=P_{\theta_1}\left[d^*/2+\theta_1<Z_1\right]$$
$$=P_{\theta_1}\left[C_1+\theta_1<Z_1\right]$$
$$\geq\frac{\beta^{\alpha}}{n^{\alpha}\left(2C_1+\beta/n\right)^{\alpha}}$$
$$\geq\left(\frac{1}{2^{1/\alpha}-1+1}\right)^{\alpha}$$
$$=\frac{1}{2}.$$

Bibliography

Carpenter, M. and Hebert, J. L. (1994), "Estimating the minimum and maximum location parameters for two gamma-exponential scale mixtures," *Communications in Statistics, Theory and Methods* 23(8), 2367-2377.

Carpenter, M. and Hebert (1996), "Estimating guaranteed lifetimes of systems in a random environment," *Communications in Statistics, Theory and Methods* 26(2) (To appear).

Carpenter, M., Pal, N.and Kushary, D. (1992), "Estimating the smaller and larger of two exponential location parameters," *Communications in Statistics, Theory and Methods* 21(4), 881-895.

REVERSE ORDER CANONICAL CORRELATION APPLIED TO REMOTELY SENSED IMAGERY

Mark Carpenter
Department of Mathematical and Information Sciences
Sam Houston State University
Huntsville, Texas 77341

KEYWORDS: Principal Components; Min/Max Autocorrelation Factors; spatial autocorrelation; pixels; satellite imagery.

ABSTRACT

Digitized data produced from remotely sensed imagery via satellite, such as LANDSAT-5, is typically highly dimensional. Accordingly, much effort is made towards reducing the dimensionality of the data. Linear transformations such as the principal component transformation are quite popular. A principal component analysis (PCA) ostensibly serves in achieving three concomitant goals. First, as mentioned, it can transform the data from dimension p to data of dimension q ($q \leq p$), without much loss of important information, i.e., the variance structure can be approximately reconstructed with fewer variables. Second, the interpretations of the coefficients and subsequent viewing of the principal component images can aid in discerning important ground features. Third, the resulting variables are uncorrelated. However, because a PCA is conducted on the global variance/covariance matrix only, it ignores local ground features and spatial correlations. Recently, a spatial correlation analog to PCA called Min/Max Autocorrelation Factors (MAF) has been introduced. A MAF is a linear transformation with coefficients that result from a reverse order canonical correlation analysis on the multivariate spatial autocorrelation matrix. MAF's produce the same desired properties as PCA's, but they possess the added feature of being invariant to changes in scale. In this paper, we discuss the theoretical differences between these analyses and compare and contrast their application to an actual LANDSAT-5 image.

~~Submitted~~ Accepted for presentation at the American Statistical Association Joint Statistical Meetings in Anaheim, August 1997

Statistical Descriptions of Digitized Satellite Imagery

Mark Carpenter

Mark Carpenter is Assistant Professor of Statistics, Department of Mathematical and Information Sciences, Sam Houston State University, Huntsville, Texas 77341. E-mail address is mth_dmc@shsu.edu. This research was partially supported by the Department of Defense, Department of Energy, and the Environmental Protection Agency under the Strategic Environmental Research and Development Program (SERDP).

Submitted to Journal of The American Statistical Association, Case Study + Application section.

OPTIMAL CLUSTER NUMBER IDENTIFICATION IN UNSUPERVISED CLASSIFICATION OF SATELLITE IMAGERY

Paul Cornils and Mark Carpenter
Department of Mathematical and Information Sciences
Sam Houston State University
Huntsville, Texas 77341

KEYWORDS: Dendogram; Cubic Clustering Criteria; Pseudo-F; Pixels; Remote Sensing

ABSTRACT

Clustering or unsupervised classification is an important exploratory tool for monitoring our environment. The most significant benefit of unsupervised classifcation is the economical savings, because unlike supervised classification there is minimal emphasis on the gathering of ground-truthing information. When ancillary data is available, clustering techniques have been successfully applied in the creation of fairly accurate classification maps from digitized satellite imagery. In the area of change detection, clustering an image that is created by differencing the corresponding pixel values of two or more temporally different satellite scenes, is helpful in detecting various levels of changes or impacts to our environment. However, the proper identification of clusters is heavily dependent upon the choice of clustering methods, such as Ward's, average linkage, etc., and, within the framework of each method, the proper identification of the optimal number of clusters. Since remote sensing devices on satellite platforms gather measurements from several areas of the electromagnetic spectrum, the resulting digitized data is multivariate with complicated correlation structures. Many of the optimal cluster number diagnostics ignore the multivariate relationships between channels and are applied univariately variable-by-variable. In this paper, we examine the performance and implementation strategies of common multivariate optimal cluster criteria. In addition, we compare and contrast the performance of cubic clustering criteria and the pseudo-F with the visual dendogram strategy. The emphasis is in both developing a theoretical framework and application to an actual LANDSAT-5 image.

Accepted for presentation at the American Statistical Assoc. Joint Stat. Meeting in Anaheim, August 1997.

Alternative Weighted Distance Functions in Classification Analysis

TIM WOLFF
APPLIED LOGIC & ASSOCIATES, INC. HOUSTON, TEXAS
CECIL HALLUM
SAM HOUSTON STATE UNIVERSITY
HUNTSVILLE, TEXAS

October 1, 1997

ABSTRACT. Various weighted distance functions are investigated for classification purposes. With optimization goals such as that of minimizing intraset distances while maximizing interset distances between classes of objects, specific transformations are obtained that improve classification results when compared to a number of classical contenders including minimum Bayes risk as well as various supervised and unsupervised classification techniques. Results are provided from applications to several differing data sets i :cluding the Fisher iris data to applications in satellite remote sensing. The rpproach is nonparametric in form and the results are highly encouraging.

1. INTRODUCTION

Multivariate classification analysis is concerned with the assignment of an unknown vector into one of two or more populations. Classification functions, under conditions of equal aprori probabilities and costs of misclassification typically resort to ratios of probability densities, say $f_i(x)/f_j(x)$, or they may rely on various distance functions such as the Mahalanobis distance,

$$(x - \overline{x}_i)' S_i^{-1} (x - \overline{x}_i) \tag{1}$$

where $\overline{x}_i$ and S_i are the sample mean and variance-covariance matrix for the ith class of objects, respectively; they may rely on a linear function such as

$$(\overline{x}_i - \overline{x}_j)' S_{pooled}^{-1} \cdot x - (1/2)(\overline{x}_i - \overline{x}_j)' S_{pooled}^{-1} (\overline{x}_i + \overline{x}_j) \tag{2}$$

where S_{pooled} is the pooled sample variance-covariance matrices for populations i and j. These classification functions are used to form classification rules that categorize a new object [1] into one of several classes. A key objective of discriminant analysis is to separate two populations as much as possible. Discriminant functions include classics such as Fisher's linear discriminant function,

To Appear: Proc. of Joint ASA Meetings

USING CLUSTER AND CLASSIFICATION ANALYSES TO DETECT THE IMPACT OF MILITARY TRAINING ON THE ENVIRONMENT

Paul Plank, Mark Carpenter and Jaimie Hebert
Sam Houston State University
Department of Mathematics
Huntsville, Texas 77341

1. Introduction

In this paper, we discuss various characteristics of a Landsat-5 image, provided by TRIES, taken during the fall of 1994 over the Camp Navajo Army Dep:t in Bellemont, Arizona. We begin our discussion with descriptive statistics of the digitized data. Since these statistics are calulated over the whole scene we refer to them as global statisitics. We conduct a global principle component analysis, which helps in reducing the dimensionality of the data, provides uncorrelated variables (in the sample correlation coefficient sense), and most importantly provides interesting interpretations about interchannel relationships and how they relate to various land-use and ground cover phenomenons. The last section of this report summarizes our results from an unsupervised classification (cluster analysis). The emphasis in each section is of statistical application. The statistical theory will be approached in subsequent technical reports, see Carpenter et. al (1996a,b). A 1974 aircraft photograph and the Landsat-5 image are depicted in Figure 1 on the next page.

1.1. Landsat-5 Images

We examine Landsat-5 data because of the local availabilty, spectral resolution, and the fact that Landsat-5 images contains Thematic Mapper (TM) bands. While SPOT data has a higher spatial resolution (18m x 18m) than LANDSAT-5 (30m x 30m), LANDSAT-5 contains the TM information, i.e., SPOT has four channels and LANDSAT-5 has seven. A Landsat-5 provides a multispectral image whose digitised data contains three visual channels (red, blue, and green), and four infrared channels (reflective, mid, and thermal) for each pixel. Due

to the release of archived data, LANDSAT-5 scenes are relatively inexpensive; for data acquisition information see EOSAT (1989).

To understand the relationship between a LANDSAT-5 image its corresponding geographical region, lets look at how the channels were chosen and the characteristics/properties that each is theorized to possess. For more details about the multispectral design see EOSAT (1992).

Figure 1.1: Description/Interpretations of Each Channel

BAND	SPECTRUM AREA (μm)	TITLE	DESCRIPTION
1	0.45-0.52	Blue	Provides water penetration. Useful for coastal area mapping and soil-vegetation mapping.
2	0.52-0.60	Green	Visible green reflectance of healthy vegetation.
3	0.63-0.69	Red	Chlorophyll absorption in vegetation. Most important for discerning vegetation types.
4	0.76-0.90	Reflective Infrared	Near infrared reflectance in health green vegetation and water-land boundaries.
5	1.55-1.75	Mid-infrared	Vegetation and soil moisture. Helpful in discerning snow from clouds
6	10.4-12.5	Thermal (heat) Infrared	Thermal mapping, and soil mosture and vegetation studies. Often discerns aspect differentials in mountainous areas.
7	2.08-2.35	Mid-infrared	Good for discerning rock types.

1.2. Camp Navajo Description

Camp Navajo is located in Bellemont, Arizona, near Flagstaff. Water bodies are few with a some cattle tanks, small creeks, and a large seasonal lake (located on the scene but is not actually located on camp). The region can basically be described as Rocky Mountain forest, i.e., mainly Ponderosa Pine with a sparse population of Douglas-fir and Blue spruce. The terran is fairly diverse in that there are heavily forested areas, as well as, rocky, grassy and mountainous. There is also are large canyon, Volunteer Canyon. For a detailed description of the camp see McHugh (1996).

2. Global Statistical Analysis

2.1. Descriptive Statistics

The Landsat-5 image comprises 368,439 pixels (multispectral vectors of length 7) with 643 pixels across and 573 down. Figure 2.1.1 contains scattor plots of various band

combinations. Each plot seems to indicate that there are possibly some outliers in the data. In fact, based on some initial clustering studies there seems to be two groups of outliers. However, it can be seen, by looking at these values within the context of their postion on the satellite scene, that these pixels are spatially connected. Therefore, we will not drop them immediately from any global analysis such as principle component analysis (PCA) as these seem to be reflective of geophysical phenomenon. In Table 2.1.1 below, we have some basic descriptive statistics derived from the whole satellite scene.

Table 2.1.1 (a): Simple Statistics of the LANDSAT-5 Image

Band	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
1	60.14	7.08	39	255
2	27.67	4.73	12	255
3	32.16	7.60	11	255
4	53.81	6.51	5	255
5	86.04	23.94	2	255
6	143.53	8.36	123	185
7	41.88	15.58	0	255

Table 2.1.1 (b): Correlation Matrix Between Band 1 - Band7

	Band						
Band	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1	1.000						
2	[redacted]	1.000					
3	[redacted]	[redacted]	1.000				
4	0.442	0.536	0.469	1.000			
5	0.803	0.801	0.853	0.562	1.000		
6	0.734	0.698	0.770	0.225	0.705	1.000	
7	0.823	0.818	0.889	0.427	0.961	0.778	1.000

The Table 2.2.1 (a) presents a maximum value of 255 for Bands 1-7, excluding Band 6. These extreme values (the maximum intensity possible for any band) are given by the group of 65 supposed outliers discussed above. We chose not to exclude these values from the analysis because after deleting these values the simple statistics, correlations, and priciple components to not seem to be affected very much by their inclusion. However, as we go through the analyses, special attention will be given to this group of 65 strange values.

Table 2.1.1 (b), contains the correlation structure associated with the seven bands. Each of these correlations tested significant at the 0.0001 level. Note that all of the correlations are positive. Also, the visual channels (Blue, Green, and Red) have the highest interchannel correlations, see the shaded region above.)

Table 2.1.1: Simple Statistics of the 65 possibl outliers

Band	*Mean*	*Standard Deviation*	*Minimum*	*Maximum*
1	207.23	42.66	132	255
2	148.06	67.09	72	255
3	166.45	60.86	90	255
4	155.72	63.32	85	255
5	218.40	36.54	136	255
6	147.38	14.41	123	172
7	175.91	57.34	84	218

Table 2.2.2 (b): Correlation Matrix Between Band 1 - Band7
For the 65 possible outliers

	Band						
Band	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1	1.000						
2	[redacted]	1.000					
3	[redacted]		1.000				
4	0.833	0.992	0.987	1.000			
5	0.437	0.645	0.650	0.662	1.000		
6	-.522	-.710	-.670	-.710	-.638	1.000	
7	0.655	0.890	0.894	0.902	0.862	-.761	1.000

2.2. Principle Component Analysis

A principle component analysis basically involves a transformation from the orginal variables to a new set of variables of the same number, called principle components. The principle components are linear combinations of the original variables such that the new variables are uncorrelated, the sum of the variances of the principle components is equal to the sum of the variances of the original variables. The principle components are also ordered in the sense that the first accounts for the largest amount of variability, the second accounts for the second largest amount, etc. For detailed discussions and theoretical development of principle component analysis, see Carpenter et. al (1996) and Seber (1984)

The benefits of doing a principle component analysis with respect to image processing/interpretation are three-fold. The first is of reduction of dimensionality. If the first few principle components account for a substantial proportion of the variability in the original p variables, then there should be little information lost by doing subsequent analyses on the

smaller set of principle components. Second, the coefficients (eigenvectors) provide interesting interpretions as to how each variable contributes to the first few principle components. These interpretations are particularly useful in remote sensing in that they can provide a profile of the land-use or other geophysical phenomenon. That is, the relationships between bands of a multispectral data set are different for different vegetation canopies on the ground. Third, the fact that the principle components are uncorrelated is helpful for many reasons. To provide validity, most of the reasonable unsupervised classification dianositics require that the analysis variables be uncorrelated. This is particularly important when deciding the optimal number of clusters, see Section 3.

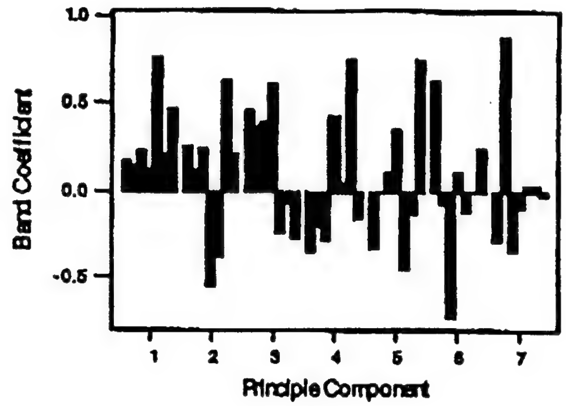
In light of the above discussion, to gain insights into the Navajo Camp site, we now conduct a principle component analysis on the data provided by the LANDSAT-5 image. The PCA is summarized below in Tables 2.3 (a) & (b).

Table 2.2.1 (a): Proportion of Variability Due to Each Principle Component

	Eigenvalue	Proportion	Cumulative
	950.365	0.8978	0.8978
	49.472	0.0467	0.9445
	32.056	0.0302	0.9747
	17.033	0.0161	0.9908
	6.937	0.0066	0.9974
	1.954	0.0018	0.9992
	0.722	0.0007	1.000

Table 2.2.1 (b): Table of Principle Component Coefficients

	Principle Component						
Band	1	2	3	4	5	6	7
2	0.131	0.115	0.362	-0.205	0.001	-0.060	0.891
4	0.113	-0.536	0.609	0.432	0.350	0.105	-0.089
6	0.208	0.623	0.063	0.740	-0.127	-0.005	0.033



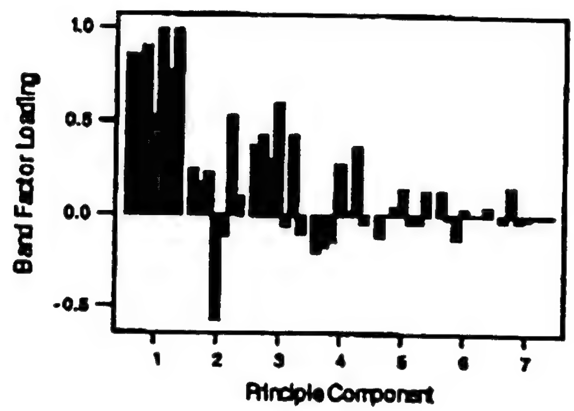
Expanding the first and second PC (accounting for 94% of the variability) gives,

$$\text{Prin1} = 0.196X_1 + 0.131X_2 + 0.233X_3 + 0.113X_4 + 0.769X_5 + 0.208X_6 + 0.496X_7$$
$$\text{Prin2} = 0.250X_1 + 0.115X_2 + 0.248X_3 - 0.536X_4 - 0.379X_5 + 0.623X_6 + 0.209X_7.$$

Also, to aid in determining how much each variable contributes to each of the principle components we look at the correlations of each band with each principle component. These numbers will tell us how each band "loads" or is associated with each principle component. Table 2.4 demonstrates the effect that each band has on the principle components.

Table 2.4: Factor Loadings for Each Band to Each Principle Component.

	Principle Component						
Band	1	2	3	4	5	6	7
[redacted]							
2	0.854	0.171	0.433	-0.179	0.001	-0.018	0.160
[redacted]							
4	0.535	-0.579	0.600	0.274	0.142	0.023	-0.012
[redacted]							
6	0.767	0.524	0.427	0.365	-0.040	-0.001	0.003
[redacted]							



Now lets examine the group of outliers a little closer. Below we give the simple statistics, sample correlation matrix, and a principle component analysis of data consisting of the 65 extreme values. We will refer back to this often in the classification section.

	Eigenvalue	Proportion	Cumulative
[illegible]	16956.7	0.8988	0.8988
[illegible]	1284.5	0.6809	0.9669
[illegible]	358.7	0.0190	0.9859
[illegible]	107.9	0.0057	0.9916
[illegible]	94.3	0.0050	0.9966
[illegible]	34.3	0.0018	0.9985
[illegible]	29.1	0.0015	1.0000

	Coefficients			Factor Loadings		
Band	**Prin1**	**Prin2**	**Prin3**	**Prin1**	**Prin2**	**Prin3**
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	0.510	-.182	-.230	0.990	-.097*	-.065*
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	0.482	-.116	-.262	0.992	-.066*	-.078*
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	-.081	-.093	0.028	-.728	-.230	0.037*
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

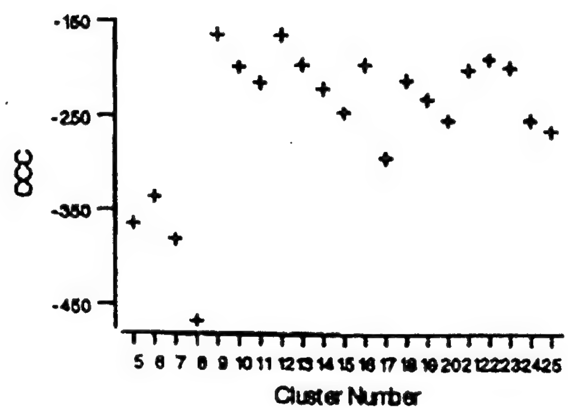
3. Unsupervised Classification

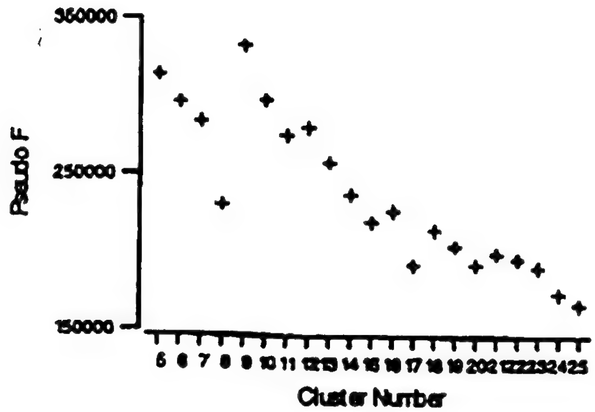
In this section, we conduct an initial cluster analysis of the Landsat-5 satellite scene. Unsupervised classification is becoming evermore popular in the world of remote sensing in that it can allow for the detection of changes in large geographic areas without the need of ground truthing. Thus unsupervised classification can save time, money and other resources.

We begin our analysis using the FASTCLUS procedure given in SAS. The FASTCLUS procedure is a derivitive of the k-means method.... First we must decide the "optimal" number of clusters to use that best describe this scene. After determining the optimal number of clusters we analyze each cluster and begin the process of identifying the signiture of each. We do this by examing the local statistics and priciple components as well as examining their spatial location on the original scene.

3.1. Optimal Cluster Number

Below are the two charts that we will use to determine the optimal cluster numbers:





3.2. Examination of Each Cluster

We begin by analyzing the "best" 16 clusters derived by FASTCLUS procedure given in SAS. Below is a summary of the clustering results. At this point, we do not consider what the optimal cluster procedures. That is, we will not debate the issue of FASTCLUS versus any other procedure. Analyzing these particular clusters will aid in understanding the spectral characteristics of this scene and assist in subsequent analyses especially analyses related to the land-use classification. The debate will be done in a subsequent report. (46 interations to converge to within 0.02 change in centroids).

[redacted]		
1	28322	9
2	430	7
3	937	11
4	7396	13
5	83912	13
6	44347	9
7	1911	11
8	8	15
9	43441	1
10	16	8
11	23320	6
12	63278	5
13	71083	5
14	15	16
15	1	8
16	22	14
Total	368439	

Notice that clusters 5,7,8,12, and 17 (total of 62 observations) are all from the set of extreme values that are discussed in the previous section. We will probably treat these as one cluster giving us a total of 13 clusters. The other 4 values are found in cluster 10.

REFERENCES

Carpenter, Mark and Hebert, Jaimie (1996a), "Adaption of Principle Component Analysis to Remote Sensing and Boundary Detection," TRIES Tech. Rep., forthcoming in June 1996.

Carpenter, Mark and Hebert, Jaimie (1996b), "Comparison of Various Unsupervised Classification Techniques Applied to Remote Sensing and Change Detection," TRIES Tech. Rep., forthcoming in Summer 1996.

EOSAT Company (1989), "EOSAT Data Archive Catelog for Previously Processed Landsat Scenes," Lanham, Md., Earth Observation Satellite Company.

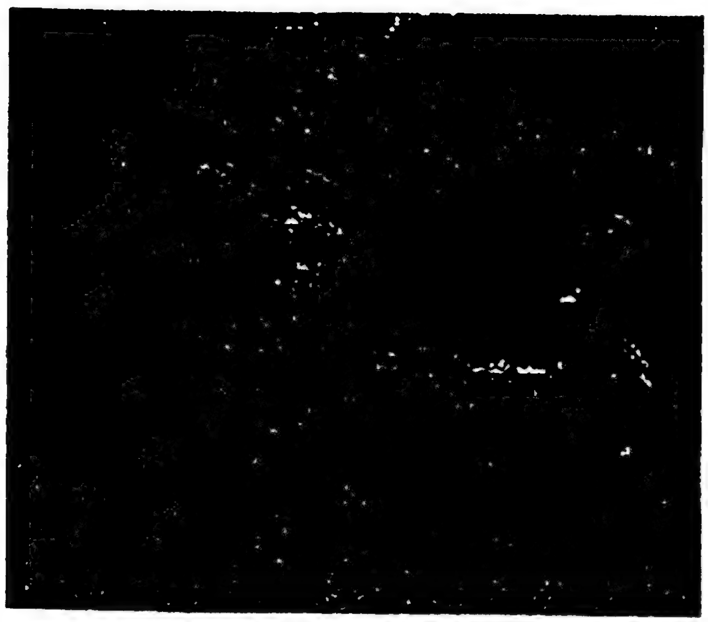
EOSAT Company (1992), "Landsat Technical Notes," Lanham MD: Earth Observation Satellite Company.

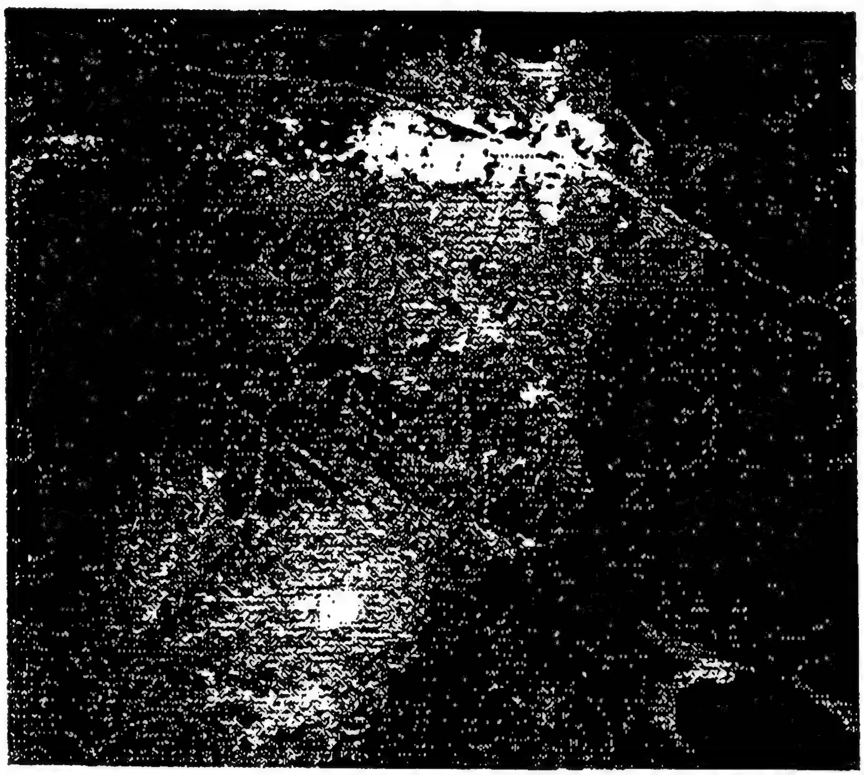
McHugh, J.P. (1996), "An Evaluation of the U.S. Army's Satellite Imagery Based Site Selection Methodology." Masters Thesis, Department of Biology, Sam Houston State University.

Seber, GAF (1984), Multivariate Observations, Wiley: New York, ISBN: 0-471-88104-X.

3 magK

Photo





CS 561.
PROPOSAL FOR MASTER'S PROJECT

Rennu George Varghese.
Sam Houston State University, 1998.

Dr. Johnny Carroll, Ph.D.
CS561 Project Advisor.

Dr. Jiahuang Ji, Ph.D.
Graduate Advisor.

1. Introduction.

Many applications of remote sensing require scientists to analyze digitized images and assess any changes that may have occurred over time. In contrast with traditional methods for acquiring and analyzing data, remote sensing techniques are cost and time effective. In addition, remote-sensing methods may well be the only alternative for gathering and analyzing information from dangerous and inaccessible sites.

Remote sensing specialists have a variety of commercial and custom made software packages available to them. The specialists are then often left with the unenviable task of learning all the individual software packages they need to use and writing format conversion programs to share data among different software packages. Other problems faced by remote-sensing professionals are the wide dispersal of data and lack of sufficient computing power to process large data sets. As Croft and Kessler (1996) note, there is a need *for "smart software"* to guide users through the complex steps required to process remotely sensed data and produce useful results.

2. *Proposed solution.*

The approach advocated by this proposal is to provide an ***integrated change assessment and image analysis toolkit*** that interested users can access and use over the Internet, with minimal hardware/software requirements and acquisition and maintenance costs. This software package is proposed explicitly with the natural resource manager (NRM) in mind. Natural resource managers are mandated by federal law to maintain and monitor the habitats of threatened and endangered species. The NRM is often required to perform image analyses such as classification and change detection/assessment. NRMs do not always have state-of-the-art hardware/software, the budget to purchase expensive image analyses packages, or the necessary time and manpower to master the bells and whistles of all the individual packages available for the tasks. ***There exists a perceived need for user-friendly means of conducting change assessment in remotely sensed data.*** This software toolkit proposed here is aimed at fulfilling exactly that need. Moreover, users no longer face issues such as software installation and maintenance.

The approach proposed here is an integrated software toolkit that can take advantage of well-known GIS packages (ArcInfo, Grass), state-of-the-art statistical packages (SAS) and new custom made software packages based on current research results. Instead of insisting that the end-user be experienced with each of these individual software programs, this toolkit packages necessary routines from these existing software tools in a user-friendly GUI environment. One of the most exciting aspects of this approach is delivery of the entire functionality of the toolkit over the Web using Java™ technology. The user has little to do in terms of maintenance of software, sufficient computing resources or integration of added functionality. The need for high performance computing machines at the user's end no longer exists. The intensive number crunching is done at the server-side. All the user needs is a computer/terminal with Internet access and a Java™ enabled web browser, however minimal.

3. *Description.*

The proposed toolkit will consist of seven basic modules designed to perform change detection/assessment and other related image analysis tasks. These modules are: Image registration, Spatial augmentation, Clustering, Change detection, Boundary detection, Estimation via Bootstrapping and Videography. While the toolkit interfaces with various packages, the user is not required to have experience with any of the packages. A user-friendly GUI allows the user to control various parameters needed by the module. Brief descriptions of the seven modules follow.

Image Registration

This module is used to align two images of the same scene taken at different times. In order to detect and assess change that occurs in two or more digitized images, it is imperative that the images be properly registered. The module assumes that one image (hereafter Image A) is geo-referenced and registered and attempts to align the unregistered image (Image B) with Image A.

Estimation via Bootstrapping.

Bootstrapping is a technique for estimating statistics such as mean, variance, or percentiles. Unlike other statistical techniques, bootstrapping makes no assumption about the distribution of the data and is therefore is quite useful in image analysis. The bootstrapping routine can be used to provide statistically defensible estimates that can be used for the change detection routine and the boundary detection routine.

Spatial augmentation.

Spatial statistics describe the correlation between neighboring pixels. One of the most common ways to use spatial methods is through augmentation. The augmented data set can be used as any other multivariate data set, but the analysis includes information regarding the spatial relationship among pixels. The only parameters controlled by the user are weights in the averaging process. The default mode is to use simple averaging.

Clustering.

Clustering (also called classification) is a method whereby pixels with similar properties are grouped together. The clustering module allows the user to select form a wide variety of clustering techniques as well the as control the number of clusters. The module is designed to allow for either supervised or unsupervised classification. The routine can also be asked to generate a dendogram that can be used to assist the user in selecting the optimal number of clusters.

Boundary detection.

This module searches for edges in a data set. The program allows the user to input an image file and then choose among different options in the detection process. The module can be used on a remotely sensed data set or on output from the change detection module to find edges of change in severity files. Wavelets are the primary tool used to detect boundaries. The user can either view the boundaries alone on a black background or overlay the boundaries on the original image.

Change detection.

A key objective in remote sensing is the ability to read landscape changes in an automated fashion. The change detector is a tool for use by image analysts and other researchers to assist in ascertaining temporal changes between two images of the same scene. This component of the toolkit assumes the user has two separate remotely sensed data sets that differ temporally. Typically, the module returns image files for each change severity level selected. In these files, pixels that do not represent change are "blacked out." The user can also view a real-time movie of different severity level images to better understand and assess change that has occurred.

Videography.

Airborne video imagery provides many exciting opportunities for change detection. Information derived from interpreting such imagery can be used to help classify satellite images and/or validate the results of a classification or to locate features within the forest.

This module integrates video imagery with other modules in the toolkit. Hardware and software interfaces permit a user to select an area of interest from a geo-referenced map or image on the screen. Once selected, videotapes that record imagery within the area of interest will automatically be positioned at that location. The user can then view the imagery to interpret information, to compare two temporally different images of the same scene, or to do other image assessment techniques.

4. *Conclusion.*

The mission to accomplish with this project is to provide a credible integrated software toolkit to examine and assess remotely sensed data accurately and to provide flexible means of interpreting them. The primary focus has been on change assessment and techniques that facilitate the quantifiable detection of temporal changes in digitized images.

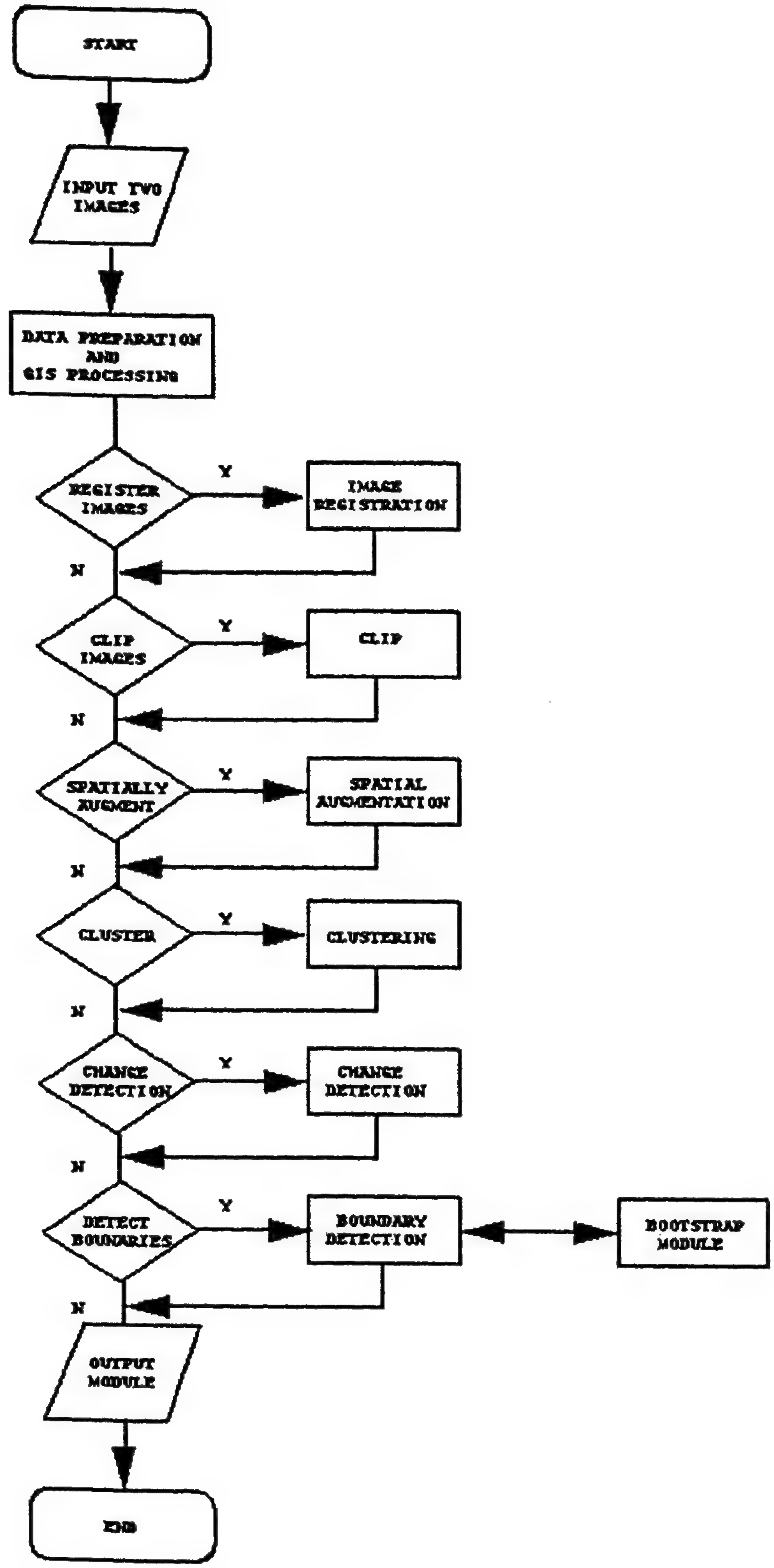
5. *Requirements for development.*

Hardware:

- SGI O2 platform.

Software:

- Java Development Toolkit (JDK1.0.2).
- CosmoCode Visual builder for Java.
- Java enabled Web browser.


START
INPUT TWO IMAGES
DATA PREPARATION AND GIS PROCESSING
REGISTER IMAGES
Y
IMAGE REGISTRATION
N
CLIP IMAGES
Y
CLIP
N
SPATIALLY AUGMENT
Y
SPATIAL AUGMENTATION
N
CLUSTER
Y
CLUSTERING
N
CHANGE DETECTION
Y
CHANGE DETECTION
N
DETECT BOUNDARIES
Y
BOUNDARY DETECTION
BOOTSTRAP MODULE
N
OUTPUT MODULE
END

Introduction

WIARS is Web Image Analysis Remote Sensing Software. The development of WIARS was funded by a contract from the Strategic Environmental Research and Development Program (SERDP). The project is a collaborative effort between Oak Ridge National Laboratory (ORNL), Construction Engineers Research Laboratory (CERL), and The Texas Regional Institute for Environmental Studies (TRIES) at Sam Houston State University. The software is being developed by faculty and students at TRIES.

WIARS is designed to assist the Department of Defense (DoD) in its commitment to the preservation of endangered species on military installations. In particular, natural resource managers are mandated by federal law to maintain and monitor the habitats of threatened and endangered species. Since many military installations are quite large in size, and some contain areas where it is impossible or hazardous to manually check these habitats, an alternative method is needed.

WIARS Software is designed explicitly with the natural resource manager in mind. The natural resource manager is the person most familiar with the habitats on the installation, and the natural resource manager should have the opportunity to use software to perform image analyses such as classification and change detection/assessment. Since many natural resource managers do not have state–of–the–art hardware/software on thier desks, nor do they have the budget to purchase expensive image analyses packages, WIARS is accessible via the World Wide Web and the heavy computations are done on a server machine. In this way all natural resource managers can access one program. Thus, the only requirement for the natural resource manager is that the Internet be available to them and that they have a World Wide Web browser (Netscape, Internet Explorer, etc.) on their computer.

WIARS allows you to log on to our site and then initialize your project. You then upload two sets of data to the server computer –– two sets are needed to do change detection/assessment. Typically, each set of data is aerial or satellite imagery of a military installation obtained at different times. You can also provide masks (for training supervised classification or excluding areas), Geographical Information Systems (GIS) layers (roads, boundaries, species' habitats), or digital video. After transferring the data to the server computer, you can view different parts of the images, overlay masks or GIS layers, view vegetative indices, or clip a certain area for further analysis. You then select the tools you want to use to analyze the data. You can use a statistical technique called spatial augmentation to enhance the data for subsequent use, classify the data into various clusters, provide a training mask (known woodpecker habitats, for example) and search for similar areas, or perform change detection/assessment. After preprocessing, you can view classification maps and/or detected change images or view videography and compare that to detected change. The software allows you to overlay various images or create movies/slide shows of images in order to help you better understand the results of your work. Now that you know what to expect, go ahead and take a look at the program.

Location

The first thing you need to know about WIARS is where to find it. This software can be reached when you type http://bayesian.shsu.edu/~wiars/client/ in the "Location" box of your browser. This will take you to the initial screen (Figure 1) of the WIARS program.

Initial Screen

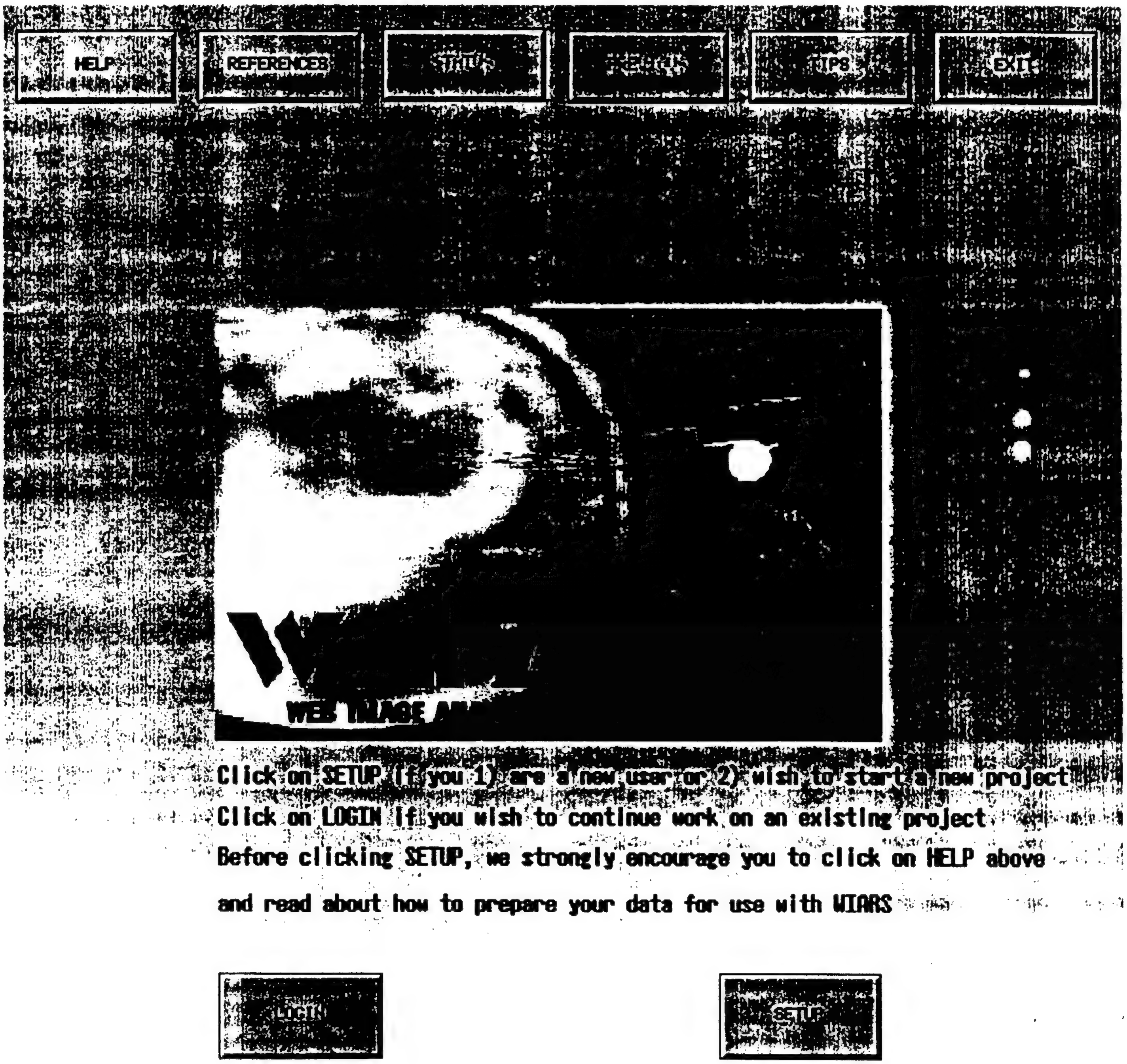


Figure 1 – The WIARS Initial Screen

When the initial screen comes up, you will see a bar of buttons (Figure 2) across the top, which appears on every major WIARS screen. Before continuing with the initial screen, you should become familiar with how to use this bar of buttons. The "Help", "Status", and "Tips" buttons all launch new browsers when clicked.

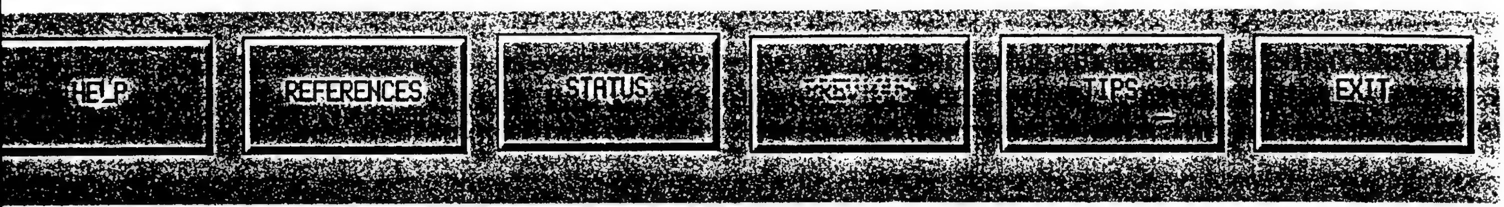


Figure 2 – Bar of Buttons on Every Major WIARS Screen

Help

The "Help" browser displays help about the screen you are currently viewing. Each help screen has links that will take you to either the previous help screen, the next help screen, or the table of contents. Go ahead and click on "Help" now. Familiarize yourself with the navigation of this page, and then either minimize or close the "Help" browser. If you minimize the browser, it will remain on the screen, and you will no longer have to click on the "Help" button. Simply click on the browser whenever you need it. It will automatically go to help about the screen you are currently viewing. This is convenient, but it will, however, take up extra memory on your computer. If you close the browser, you will need to click on the "Help" button again the next time that you need to launch the "Help" browser.

References

The "References" browser displays a list of various references related to this software.

Status

The "Status" browser displays all of the work completed on the current project to date. Since some of the processes performed in this program can take a very long time to complete, this button is very useful in determining if the program is still running and where it is in the process. Notice that the "Status" button is disabled on the initial screen because you have not uploaded any data yet.

Tips

The "Tips" browser displays useful little tips dealing with the screen you are currently viewing. Notice that the "Tips" button is disabled on the initial screen.

Previous

If you click on the "Previous" button, you are taken back to the previous major screen of the program where you can either make changes or clarify commands that have been

issued. Notice that the "Previous" button is disabled on the initial screen because there is no previous screen.

Exit

If you click on the "Exit" button, you are allowed to exit the program. All work you have done on a project will be saved so that you may return and continue working on the project at a later time.

Now that you know how to use this bar of buttons, you can continue with the initial screen. This screen also consists of the WIARS logo and "Login" and "Setup" buttons. The "Login" button allows you to work on a project already in progress. The "Setup" button allows you to start a new project. Since you are a new user, click on the "Setup" button. This will bring you to the setup window (Figure 3A).

Setup Window

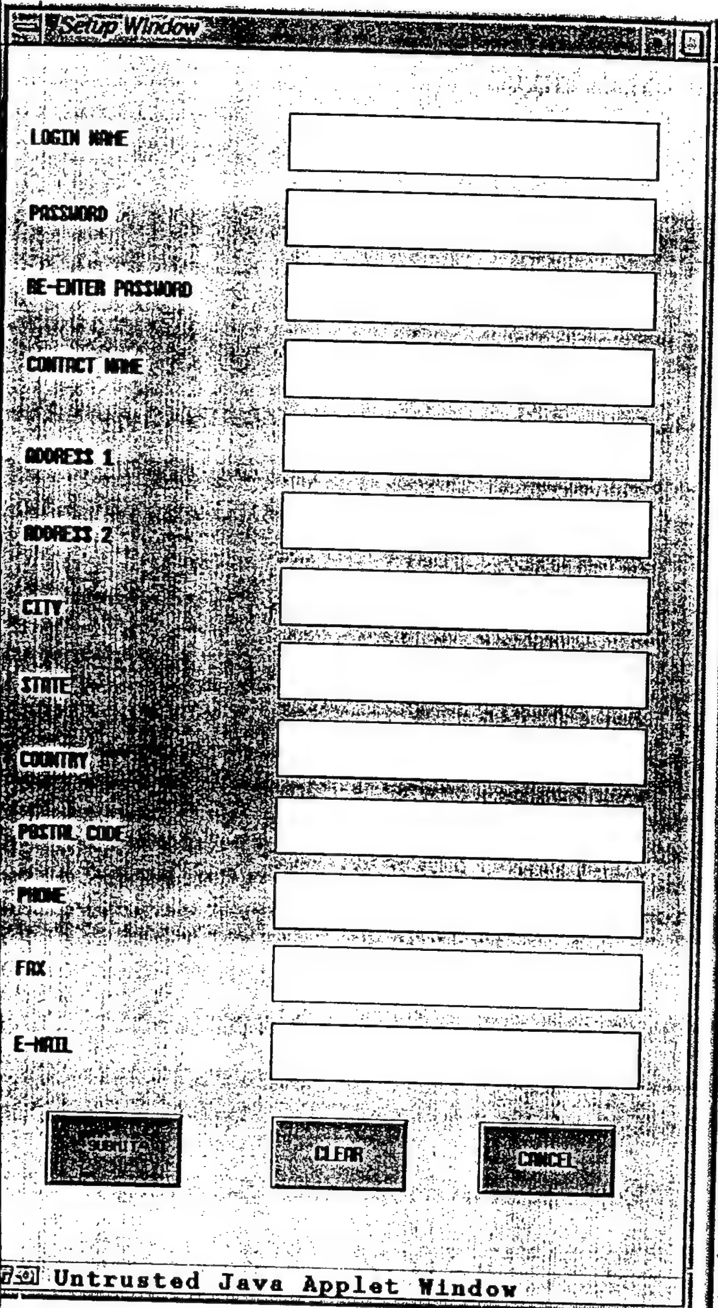


Figure 3A – The WIARS Setup Window (blank)

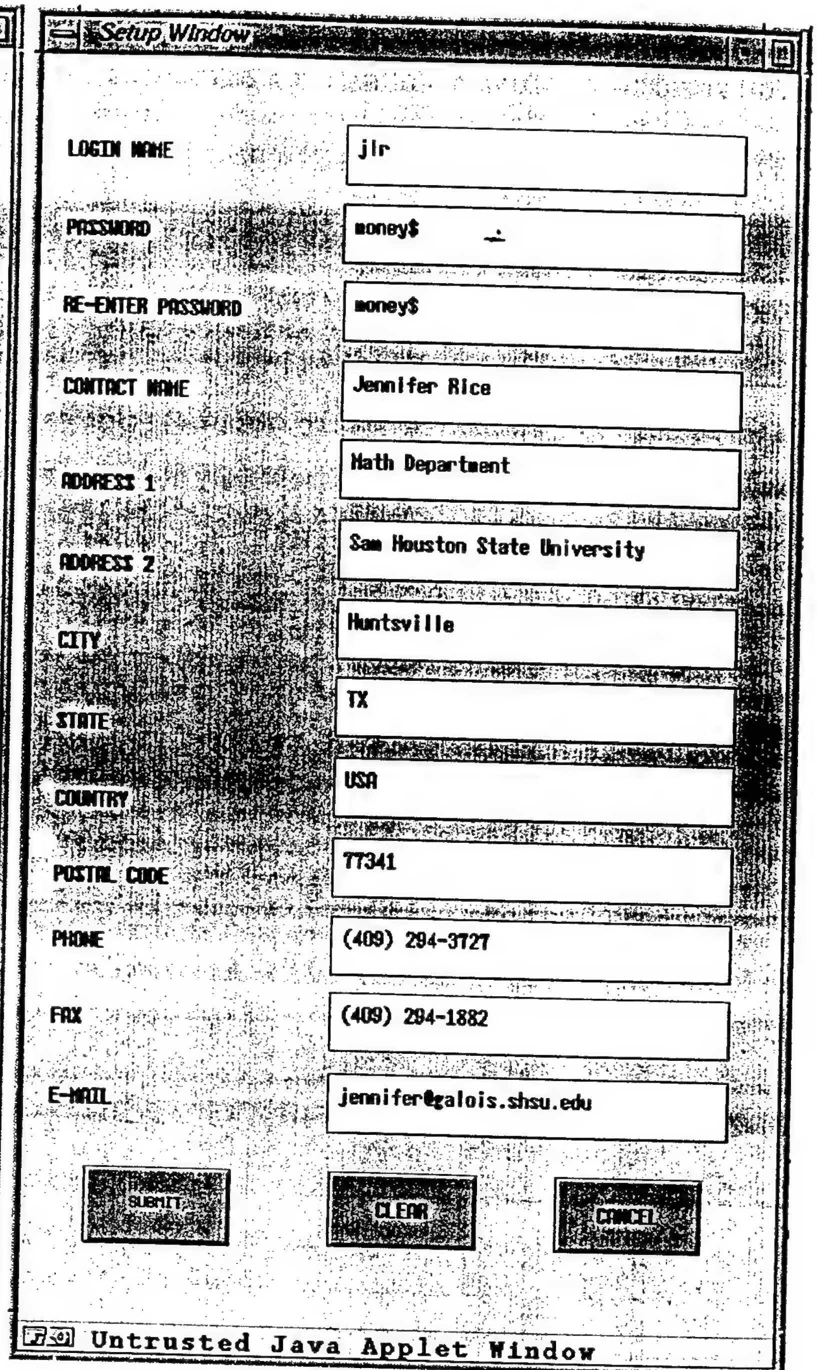


Figure 3B – The WIARS Setup Window (filled in)

The setup window asks you to provide some basic information such as a login name, a password, and a contact name with a mailing address, phone and fax numbers, and an e–mail address. If you make a mistake while entering your information, you can click on the "Clear" button. This will delete all information currently on the screen and allow you to begin re–entering your information. If you click on the "Cancel" button, all information currently on the screen will be deleted, and you will automatically be taken back to the initial screen. Enter the information requested below. Use your initials as your login name and also give a password of your choice. The password must be six or more characters with at least one numeric or special key. For example, my name is Jennifer Leigh Rice, so I will use "jlr" as my

login name and "money$" will be my password. After you have all of your information entered correctly in the setup window, you can click on the "Submit" button which will take you back to the initial screen. Now, you can click on the "Login" button that will bring up the login window (Figure 4A).

Login Window

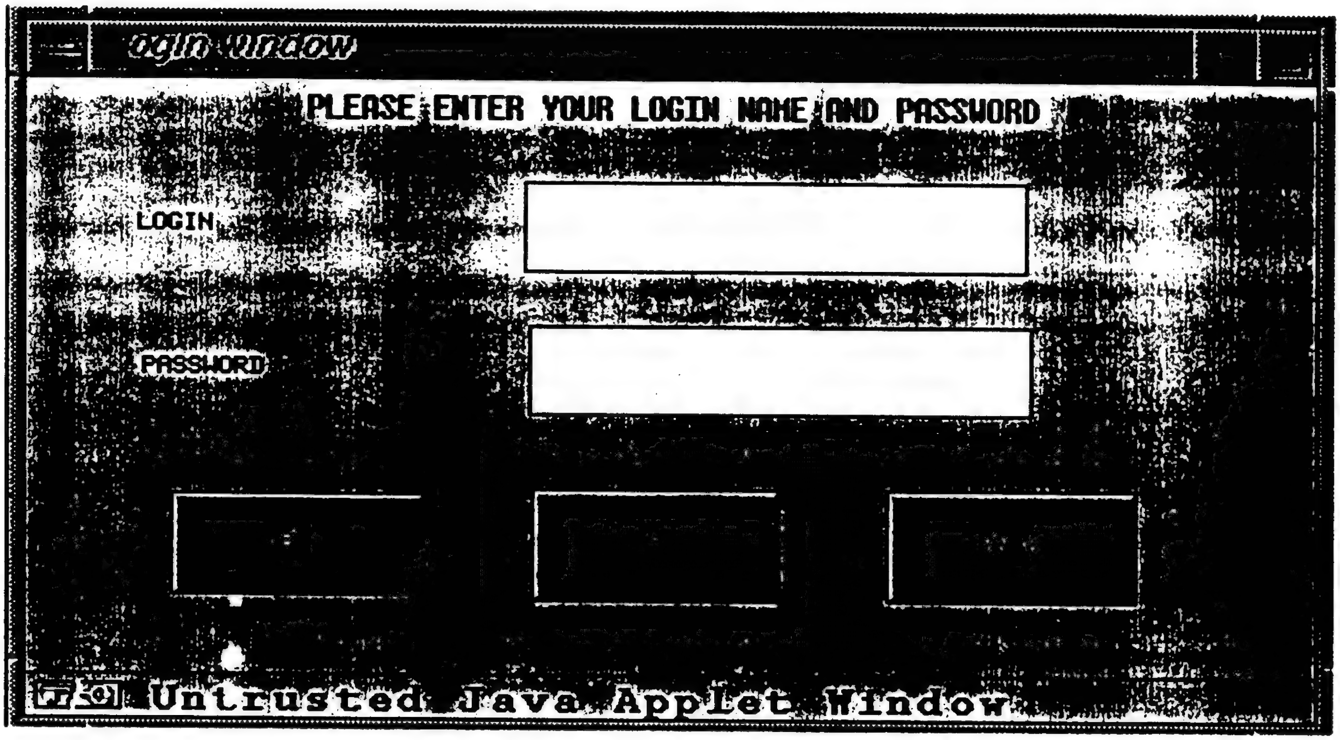


Figure 4A – The WIARS Login Window (blank)

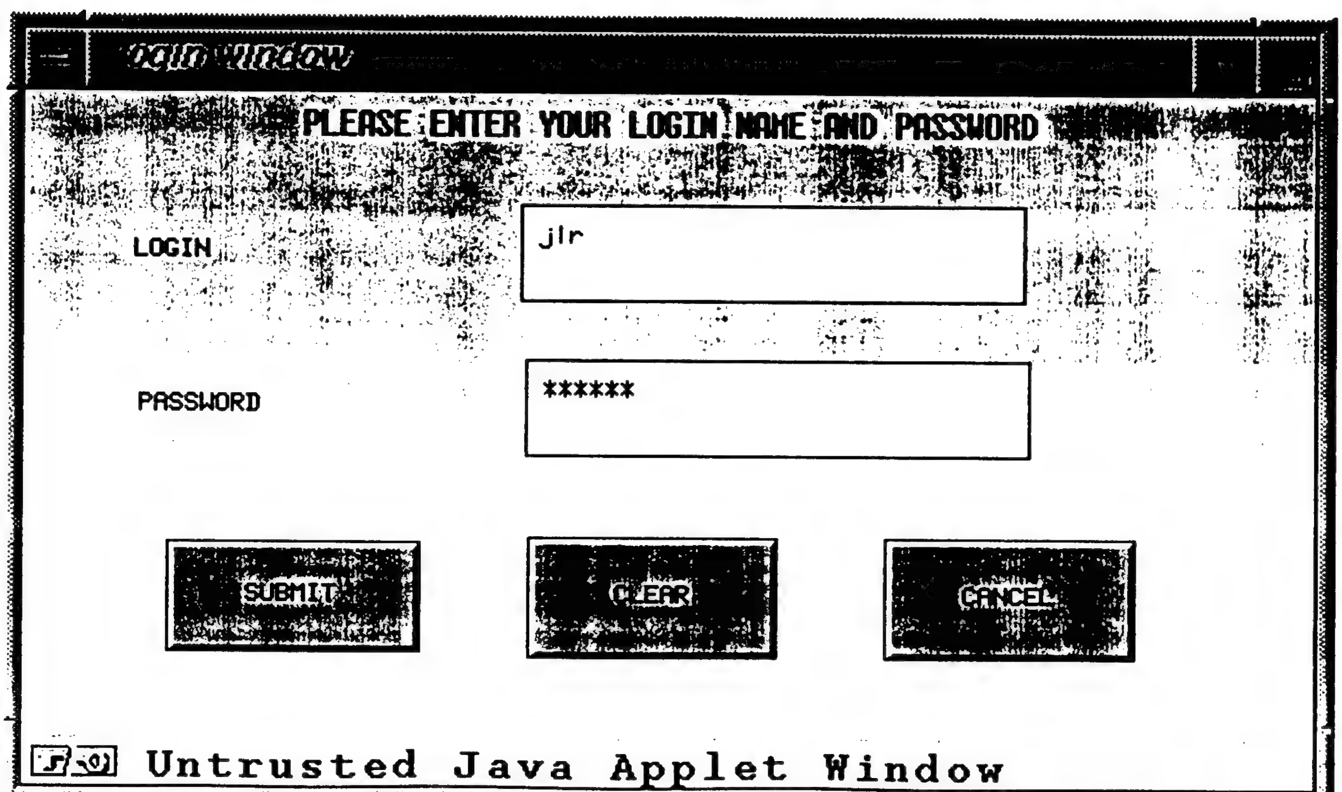


Figure 4B – The WIARS Login Window (filled in)

In the login window, there is a place for you to type in your login name and password exactly the same as you did in the setup window. The "Login" and "Password" boxes in this screen are case sensitive. For example, since I typed "jlr" as my login name and "money$" as my password in the setup screen, then "JLR" and "MONEY$" will not work in the login window. If you make a mistake, simply click on the "Clear" button to delete the information and then re-enter it correctly. If you click on the "Cancel" button, all information is deleted and you are taken back to the initial screen (Figure 1). When your login name and password have been correctly entered in the login window, click on the "Submit" button. This will take you to the project manager window (Figure 5).

Project Manager Window

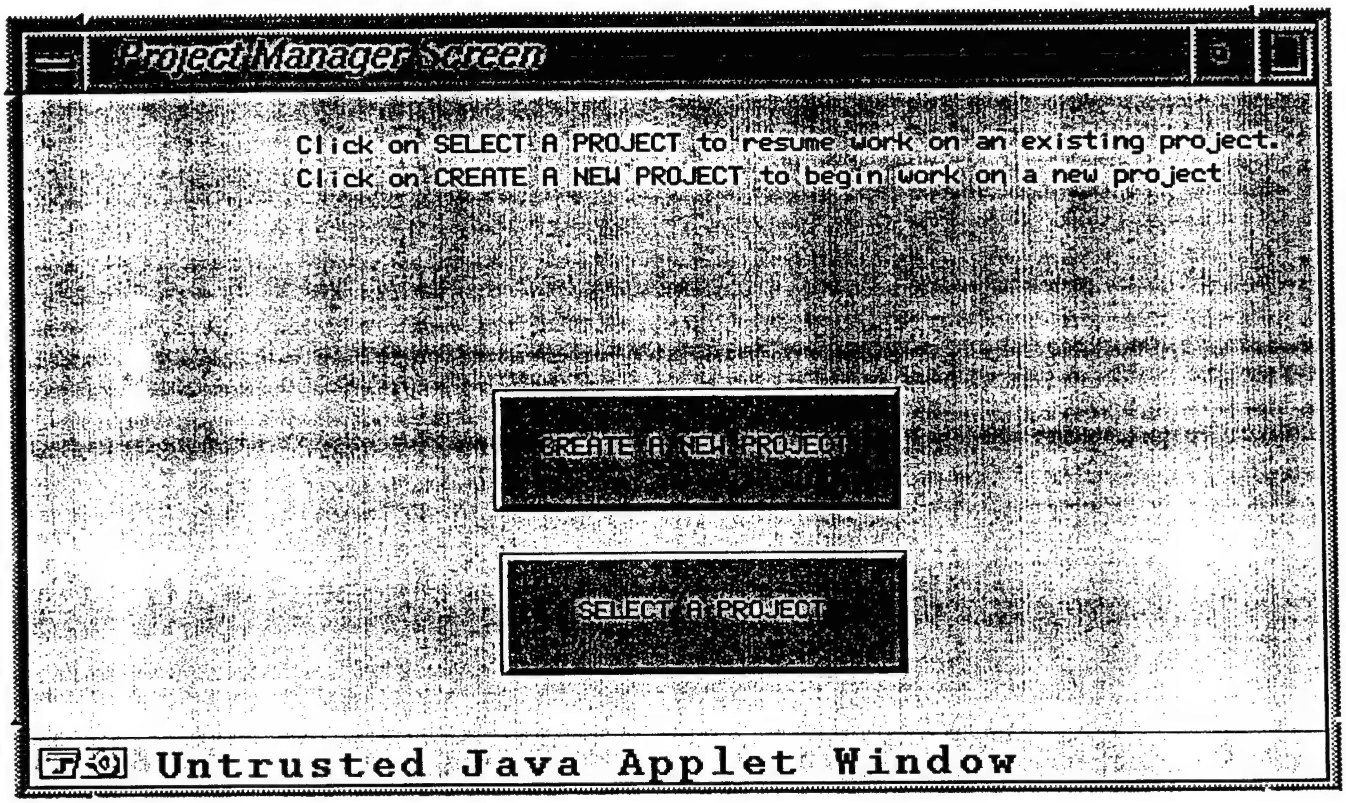


Figure 5 – The WIARS Project Manager Window

The project manager window consists of two buttons, "Create a New Project" and "Select a Project". These two buttons are self explanatory. If you click on the "Create a New Project" button, you will be allowed to set up a new project. If you click on the "Select a Project" button, you can continue work on a project already in progress. For this tutorial, click on the "Create a New Project" button. When prompted for a project name, type "tutorial". When you log in next time, you will be able to click on "Select a Project" and choose "tutorial". This will take you to the download screen (Figure 6).

Download Screen

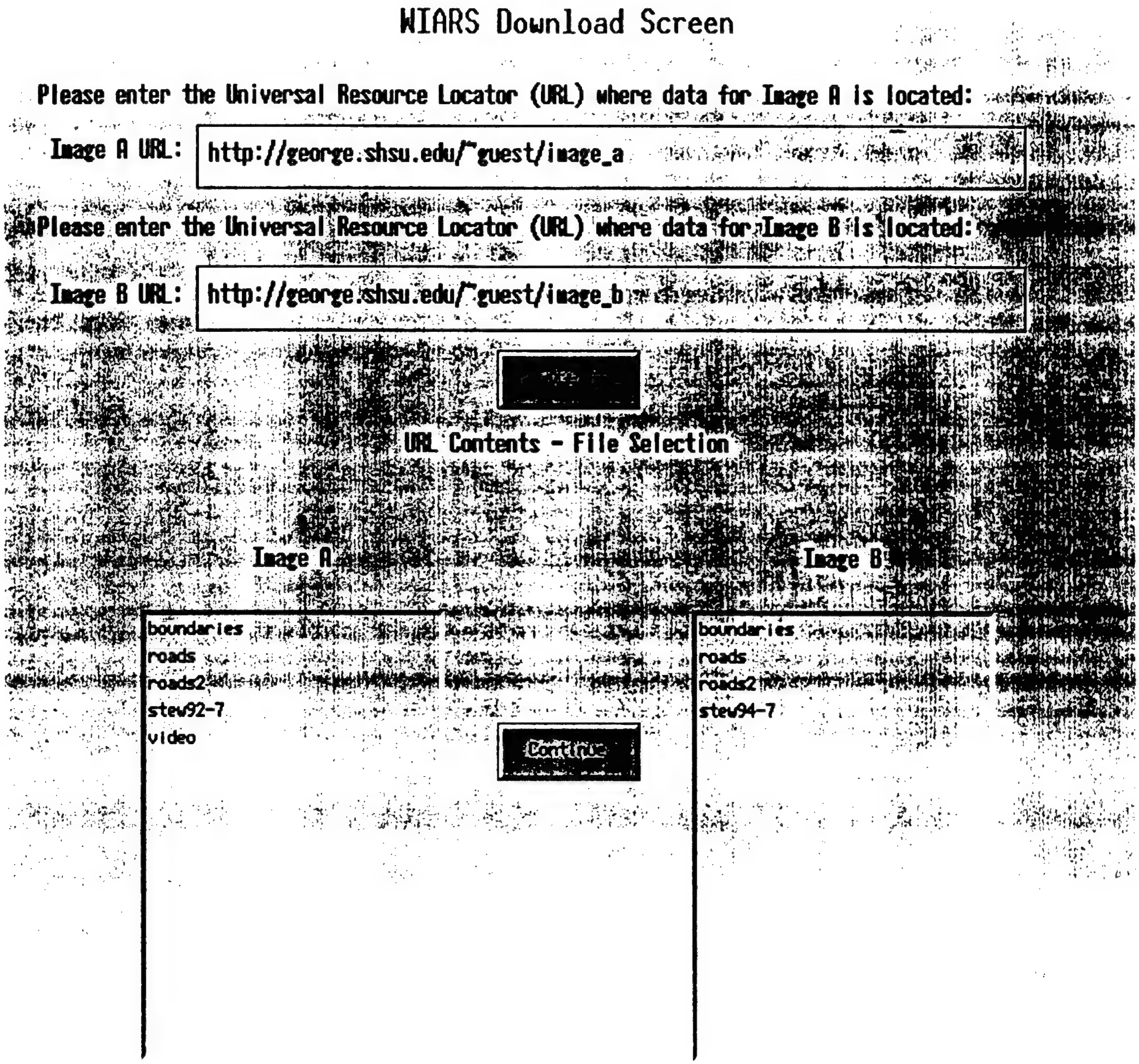


Figure 6 – The WIARS Download Screen

Now you are ready to move the data to the WIARS machine. You must tell the program where the data is by entering the Universal Resource Locations (URL) of the data for the two images that you wish to analyze. The data that will be used for this tutorial is found at *http://george.shsu.edu/~guest/image_a* and *http://george.shsu.edu/~guest/image_b*. After you enter these URLs, click on the "Submit" button. When you click on "Submit", the program finds all the files at those sites and creates two listings beneath the "Submit" button. These listings include the raw data, mask, and videography files for the first image and the raw data and mask files for the second image. Notice that there are no suffixes on these file names and that there is no videography for the second image.

Before you can cotinue with this program, you must select a file, or files, out of each of the list boxes. To do this, simply click once on the file name to highlight it in black. Then, double click on the highlighted file name. For example, click on stew 92–7. Now double click on the same file. This will pull up the image characterization dialog (Figure 7) where you give information about the files. Repeat this process for all files in both list boxes to continue with this tutorial.

Image Characterization Dialog

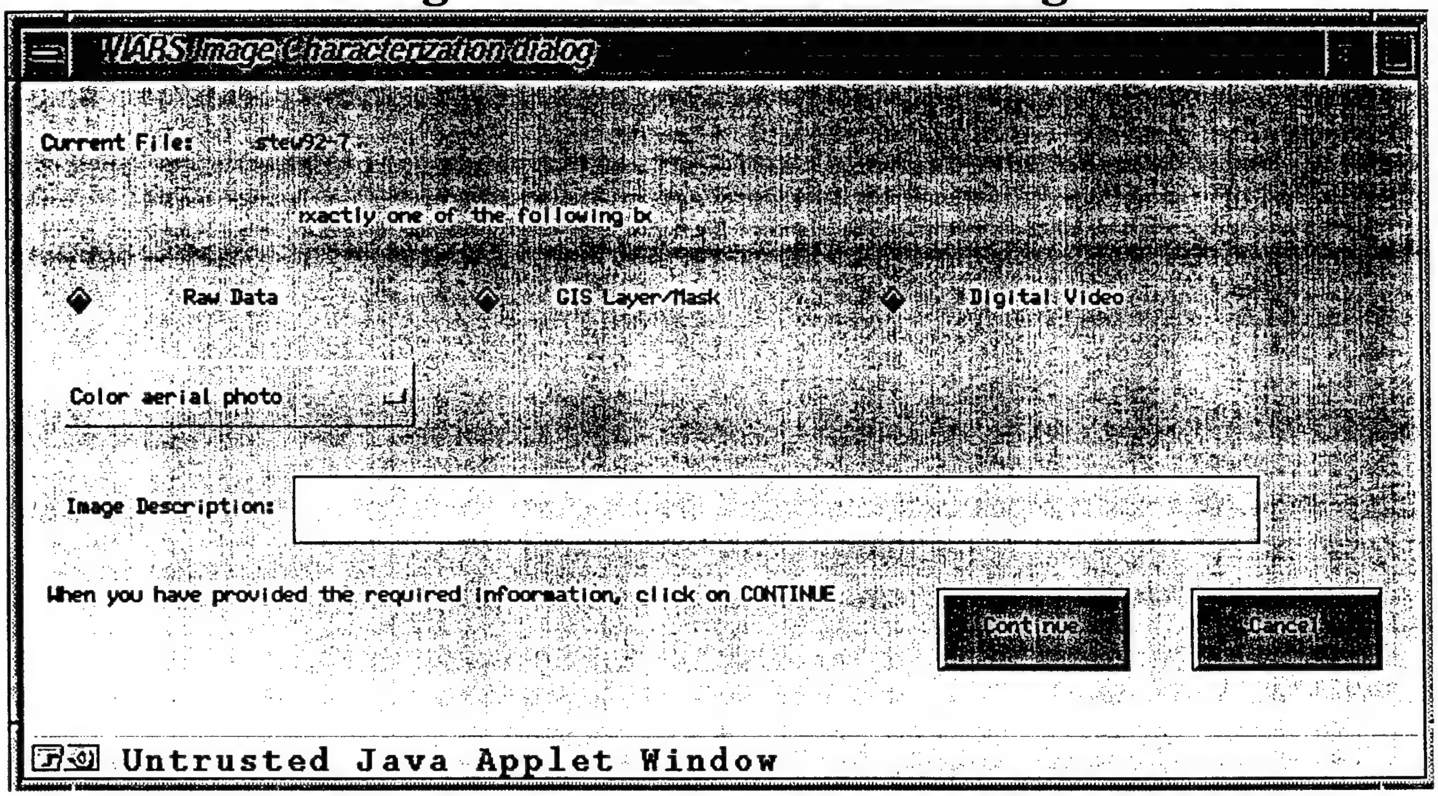


Figure 7 – The WIARS Image Characterization Dialog

In the image characterization dialog, you must complete three tasks. First, indicate whether the file you want to analyze is a bip image, a mask/GIS layer, or a digital video by checking the corresponding box. For example, you need to click on bip image for the stew92–7 file that you selected in the download screen (Figure 6). Second, select the correct choice from the pulldown menu to specify how the data was obtained. For your stew92–7 file, you need to click on LandSat TM. Finally, you need to enter a simple description of the image you wish to view. An example to type for your

stew92–7 file would be "Ft. Stewart June 1992" or some other comment. If you make a mistake while entering these descriptions, you can click on the "Cancel" button to delete that information and go back to the download screen. From there, you can select the file again and start over in the image characterization diaog. After these three tasks have been completed, you can click on the "Continue" button which will take you back to the download screen (Figure 6). Now click on "Continue" to go to the image view screen (Figure 8).

Image View Screen

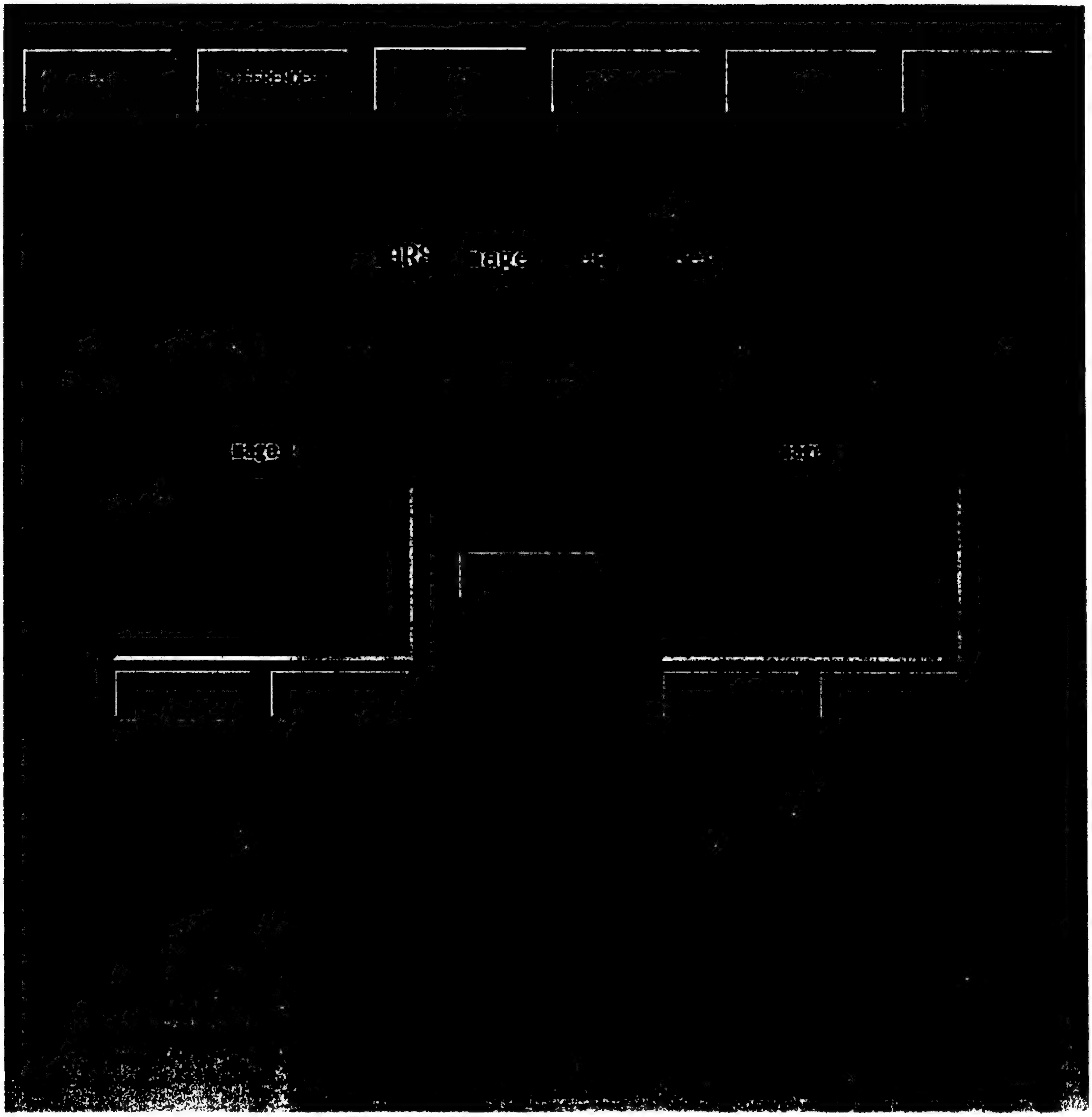


Figure 8 – The WIARS Image View Screen

The purpose of the image view screen is just to look at your data. When the image view screen pops up, you can see that the files you selected in the download screen appear in list boxes. Click on a file name once to highlight it in black. Double click on the highlighted file name, so that you can set the parameters of the image as you choose in the image view configuration screen (Figure 9). Once the parameters of the images and/or masks have been set, click on the "Submit" button to view your image. If you click on the "Clear" button, the image will disappear. You can do this process for as many images as you like. The last image you produce will show up in the image view screen (Figure 8). When you are finished viewing your images, click on the "Continue" button to go to the band/mask selection screen (Figure 11).

Image View Configuration Screen

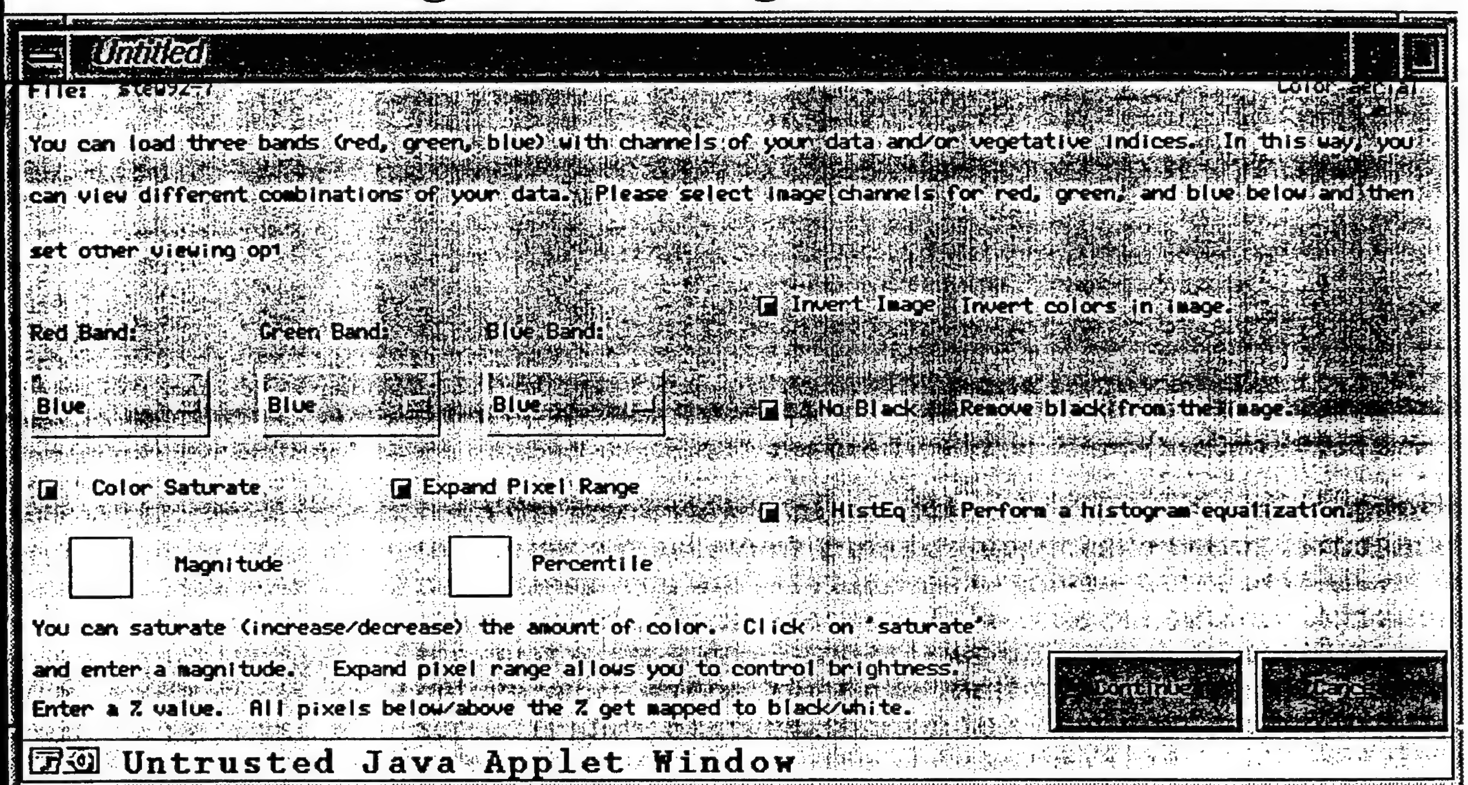


Figure 9 – The WIARS Image View Configuration Screen

In the image view cofiguration screen, you can select image channels to assign to the red, green, and blue bands of the view image to be displayed on the screen. You are allowed to choose from seven channels of information and also from some vegetative indices. If you pick the same channel in all three bands, you will get a black and white picture. You can also indicate whether or not to color saturate the image or expand the pixel range. You can also choose to invert the colors in the image (make black be white and make white be black), remove black from the image, or perform a histogram equalization that improves contrast and brightness of images. For this tutorial, pick red in the red band, infrared in the green band, and infrared minus red in the blue band.

If one of the files you selected is a mask file, the program will go to the mask view configuration screen (Figure 10) when you double click on the file name.

Mask View Configuration Screen

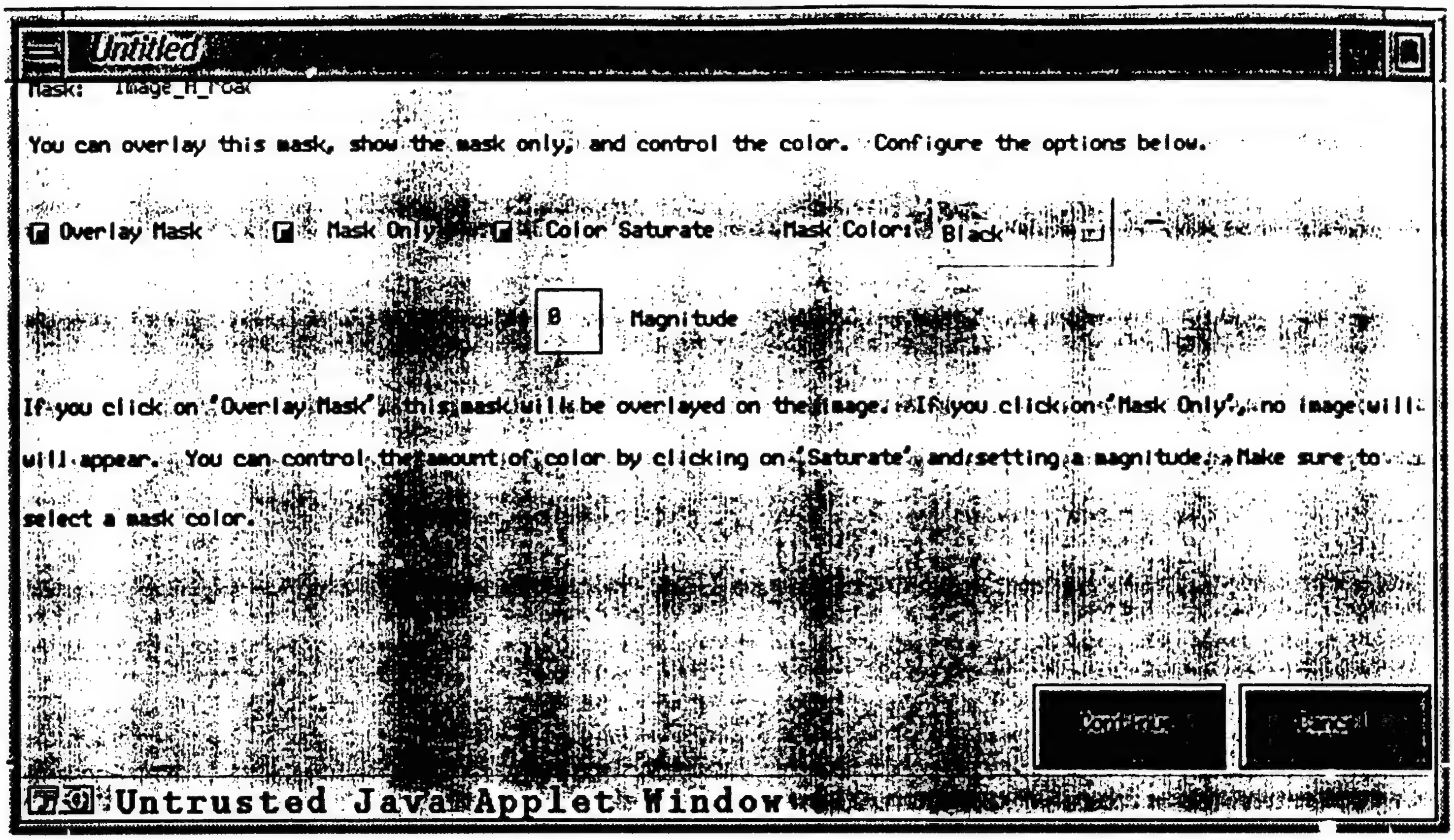


Figure 10 – Mask View Configuration Screen

In the mask view configuration screen, you are allowed the opportunity to choose to overlay a mask, view a mask only, or color saturate the image. If you decide to use a mask, you are also allowed to control the color of the mask. If you want to color saturate the image, be sure to set a magnitude. A magnitude of 2 will double the color while a magnitude of .5 will half the color. When you finish making these options, click on the "Continue" button. This takes you back to the image view screen (Figure 8). Now, click on the "Continue" button to go to the band/mask selection screen (Figure 11).

Band/Mask Selection Screen

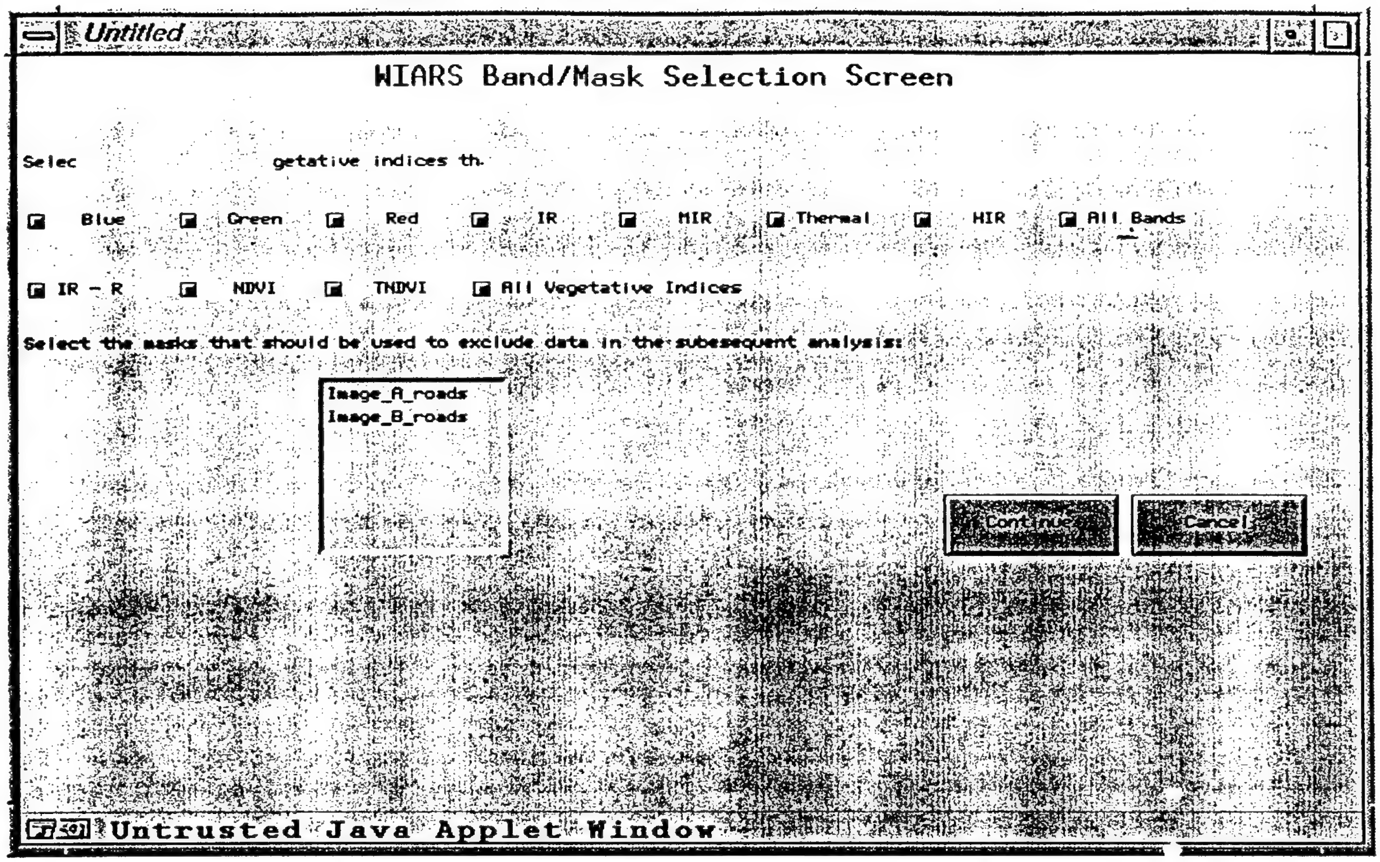


Figure 11 – The WIARS Band/Mask Selection Screen

In the band/mask selection screen, you are allowed to pick any or all of the bands, any vegetative indices, and any masks that you wish to be used in your analysis. Most people do not use the thermal channel to detect vegetative change, so for this tutorial, click on all of the bands except thermal, all of the vegetative indices, and all of the masks. Once you have checked the appropriate box(es), click on the "Continue" button. This takes you to the image clip screen (Figure12).

Image Clip Screen

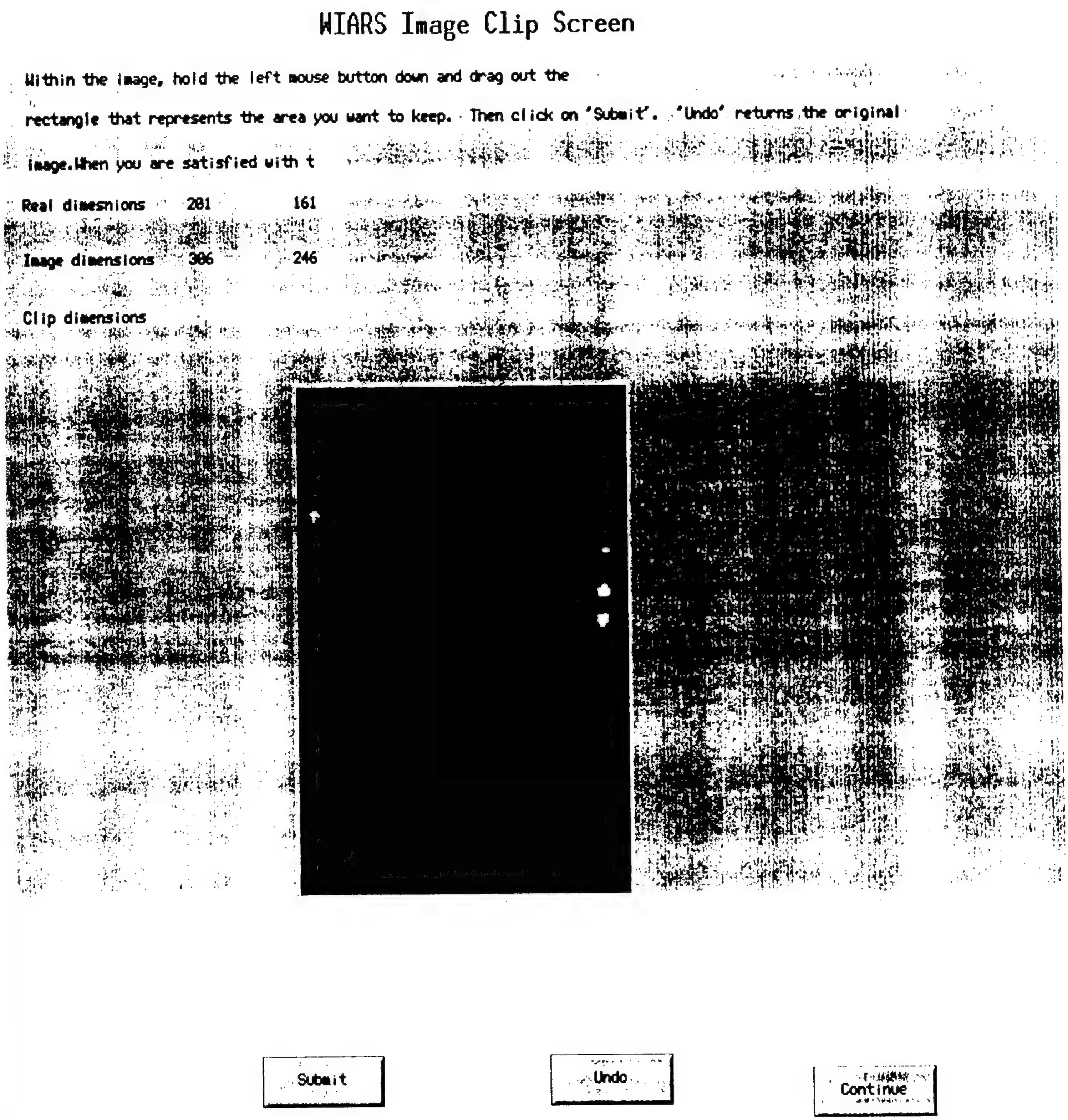


Figure 12 – The WIARS Image Clip Screen

In the image clip screen, you are allowed to zoom in on certain areas and clip the images you are viewing. You need only to clip Image A because the same clip is automatically performed for Image B. Your image is displayed in the middle of the screen. The data is actually larger than the screen, so we refit it to rows and columns dimensions. Notice that you are provided with these numbers. In the indicated boxes, you can enter the number of rows that you want to clip off the top and off the bottom of the image and the nuber of columns you want to clip off the left side and off the right side of the image. When you click on the "Submit" button, the image will reappear. The portion of the image that was kept will appear in its original color while the portion that was clipped will appear gray. If you click on the "Undo" button, the original image will be displayed. You can either choose to leave the image as it is or clip the image again.

The white area in the image you created in this tutorial is a helicopter pad; try to zoom in on that. Enter 50 rows to be clipped off of the top, 220 columns to be clipped off of the right side, 200 rows to be clipped off of the bottom, and 0 columns to be clipped off of the left side. This should make you very close to having only the helicopter pad in your image. When you are finished clipping the image, or if you do not wish to clip the image, click on the "Continue" button to move on to the preprocessing screen (Figure 13).

Preprocessing Screen

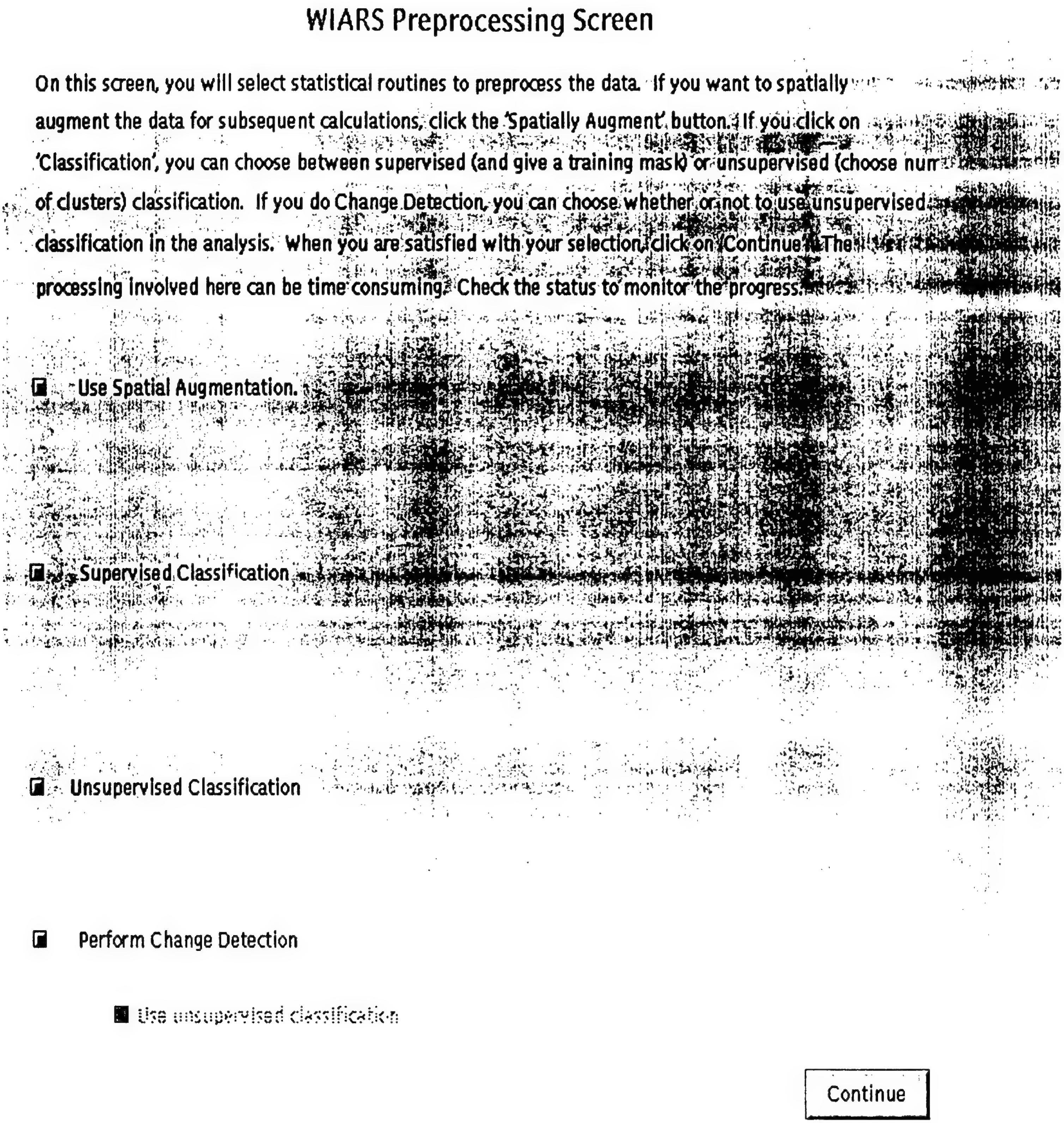


Figure 13 – The WIARS Preprocessing Screen

The preprocessing screen is the main computational part of the program. It allows you to apply some mathmatical and statistical routines to your data. You can choose to perform spatial augmentation, unsupervised classification (choose number or clusters), supervised classification (give a training mask), or change detection/assessment by clicking on the corresponding box. You can also perform more than one routine at a time; just click on all boxes that apply. Some of these processes can be time consuming, but you can check your progress by clicking on the "Status" button. When you are finished selecting routines you wish to apply to your data, click on the "Continue" button. The program will take five or six minutes to analyze the data before taking you to the output screen.

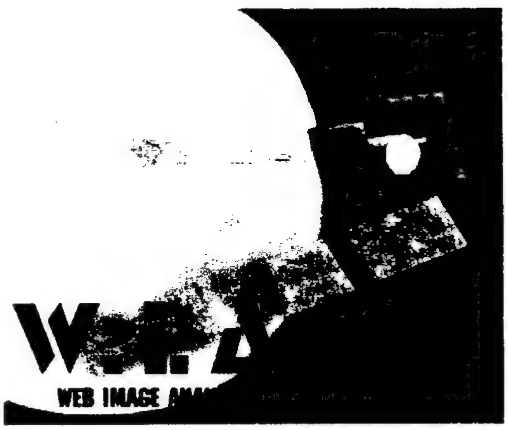
Output Screen

The output screen is the final screen of this program. It has not yet been developed, but when it has, a figure and a description will be added to this tutorial.

Welcome to *WIARS*!

General Overview

skip to the table of contents



WIARS is *Web Image Analysis Remote Sensing* Software. The development of *WIARS* was funded by a contract from the Strategic Environmental Research and Development Program (**SERDP**). The project is a collaborative effort between Oak Ridge National Laboratory (**ORNL**), Construction Engineers Research Laboratory (**CERL**), and The Texas Regional Institute for Environmental Studies (**TRIES**) at Sam Houston State University. The software is being developed by faculty and students at TRIES. To see a complete list of personnel, click here.

WIARS is designed to assist the Department of Defense (**DoD**) commitment to the preservation of endangered species on military installation. In particular. natural resource managers are mandated by federal law to maintain and monitor the habitats of threatened and endangered species. Since many military installations are quite large in size and some contain areas where it is impossible or hazardous to manually check these habitats, an alternative method is needed.

WIARS software is designed explicitly with the natural resource manager (**NRM**) in mind. The NRM is the person most familiar with the habitats on the installation and the NRM should have the opportunity to use software to perform image analyses such as classification and change detection/assessment. Since many NRMs do not have state–of–the–art hardware/software on their desks nor do they have the budget to purchase expensive image analyses packages. *WIARS* is accessible via the World Wide Web and the heavy computations are done on a server machine. In this way all NRMs can access one program. Thus the only requirement for the NRM is that the Internet

be available to them and that they have a World Wide Web browser (Netscape, Internet Explorer, etc.) on their computer.

WIARS allows users to log on to our site and then initialize their project. The user then uploads two sets of data to the server computer – two sets are needed to do change detection/assessment. Typically, each set of data are aerial or satellite imagery of a military installation obtained at different times. The user can also provide masks (for training supervised classification or excluding areas), Geographical Information Systems (GIS) layers (roads, installation boundaries, species habitats), or digital video. After transferring the data to the server computer, the user can view different part of the images, overlay masks or GIS layers, view vegetative indices, or clip a certain area for further analysis. The user then selects the tools he wants to use to analyze the data. The user can use a statistical technique called spatial augmentation to enhance the data for subsequent use, classify the data into various clusters, provide a training mask (known woodpecker habitats, for example) and search for similar areas, or perform change detection/assessment. After preprocessing, the user can view classification maps and/or detected change images, or view videography and compare that to detected change. The software allows users to overlay various images or create movies/slide shows of images in order to help them better understand the results of their work.

What follows below is a table of contents for online help. After a discussion of how to prepare data for use with *WIARS*, the help is then divided into six sections – one for each major screen in the *WIARS* program. For the user with a background in mathematics, statistics, remote sensing, detailed help is provided on each of the numerical modules that *WIARS* uses. Throughout the help, you can find flow charts to indicate how the program works.

A Note on Help

A final word on navigating through help. It is impossible to know how the user arrived at the page he or she is viewing. Therefore a back button is of no use. We have provided buttons to go back to the table of contents, back to the previous page in our documentation, or ahead to the next page in our documentation. If you want to return to the page you previously viewed, use your browser's back

button. If you wish to close your help, use the browser's close button.

<Previous Page> < Next Page>

Table of Contents

<Previous Page> <Next Page> <Table of Contents>

Before You Start – Data Preparation

Introduction

In order to successfully use *WIARS*, your data must be properly formatted. Most Geographical Information Systems (GIS) software packages can perform the conversions necessary to use *WIARS*, but if you cannot format your data to our specifications, please contact the WIARS System Administrator for assistance.

WIARS classifies data into three types: raw image data, masks or GIS layers, and digital videography. Raw image data is satellite data or aerial photography data. This is the data that shows the area you are interested in analyzing. Masks are files that *WIARS* uses for two purposes –– to serve as a trainer for supervised classification and to remove any unwanted values from the raw image data. GIS layers are files that contain information such as road location, species habitats, and installation boundaries. *WIARS* views these files as one basic type. The third type of data are digital videography. *WIARS* allows you to either connect a VCR to your computer or use digital videography to better perform your analyses. In the paragraphs that follow, each of the data types will be described.

Raw Image Data

WIARS expects three files for raw image data: the raw data file, a header file, and a world file. All three files must have the same prefix. For example, if you wanted to use data from a LandSat TM of Fort Stewart taken in 1992, you might name your raw image files stew92.bip, stew92.hdr, and stew92.bpw. The raw data file is expected to be in band–interleaved–by–pixel (bip) format. Formats for the hdr and bpw files will follow.

BIP Format

Band–interleaved–by–pixel is a simple and easy–to–use file format. Suppose your data came from a satellite and N channels are available. For example, a LandSat TM file will have 7 channels (blue,

green, red, infrared, near infrared, thermal, and high infrared channels), a color aerial photograph will have 3 channels (red, green, blue) and a greyscale aerial photograph will have 1 channel.

The image the data represents is displayed visually in a rectangular picture comprised of r rows and c columns. For each element of this image (*hereafter called a pixel*) we associate N different values. These values must range from 0 to 255 so that only one byte (an 8–bit character) is needed to store it. BIP format simply asks that you represent each of these values by a character (all characters on your keyboard are assigned numbers 0 – 255) and that you list all seven values for the upper left hand pixel first (in order), then list the remaining values for each pixel in the top row. Next, list the values for all the pixels in row 2 and so on. In all, your file should have r*c*N bytes in it.

HDR Format

The header file contains information about the BIP file. It is a very small file and can be created by a text editor if need be. It consists of eight lines. The first line denotes the number of rows in the bip image, the second is the number of columns, and the third is the number of bands. The next three lines provide information about the data structure: line four is the number of bits per pixel, line five is the byteorder, and line six is the layout. The bits per pixel for this version of *WIARS* is eight, and the byteorder is either M for Unix workstations or I for PCs. The layout is BIP. The last two lines are bandrowbytes (the number of columns for 8 bit pixels) and the totalrowbytes (bandrowbytes*nbands). A sample .hdr file follows below. You must use the descriptors (NROWS, NCOLS, etc.) when creating your header:

NROWS 500

NCOLS 750

NBANDS 7

NBITS 8

BYTEORDER M

LAYOUT BIP

BANDROWBYTES 750

TOTALROWBYTES 5250

BPW Format

The world file (bpw) allows *WIARS* to georeference the image with real world coordinates. Like the hdr file, it is quite small and consists of six numbers. The first number gives the ground resolution of the pixels in the west–east direction (for example 25 meters might be the width of one pixel). The second and third numbers indicate rotation of the image in the horizontal and vertical directions respectively. *WIARS* assumes that the images have been rectified so that the rotation values are always zero. The fourth number gives the ground resolution of the pixels in the north–south direction. A negative number indicates the vertical components move north to south. The fifth

number gives the real–world horizontal coordinate for the center of the top left hand pixel in the image. Here the coordinate is a Universal Transverse Mercator (UTM) Easting and measures the distance in meters from the origin of UTM Zone 12. The last number gives the real–world vertical coordinate for the center of the top left hand pixel. These last two numbers are important since *WIARS* will attempt to co–register two images that have different fifth and sixth values. A sample bpw file follows:

25.000000

0.000000

0.000000

−25.000000

415918.2171000001000

3554316.2790999999900

Mask Files/GIS Layers

Mask files and GIS layers have various uses as described above. The format for each mask is exactly the same as raw image data with a few minor exceptions. The mask itself should be stored in a one band bip file where the only entries are character 0 (excluding corresponding image pixel) or character one (including corresponding image pixel). The hdr file is just like the image hdr (except NBANDS = 1) and the bpw file is exactly the same as the image bpw file. As in the case with image files, one prefix should be used. For example, a GIS layer of roads might look like roads.bip, roads.hdr, or roads.bpw.

Digital Videography Files

If you wish to use digital videography , you must use the Arc/ Info Interchange format. *WIARS* connects with Arc/ Info to run the videography portion of the program. For more information on the Arc/ Info Interchange format, please consult the reference page.

Other Specifications

WIARS assumes that you have two different images. For the present version of *WIARS*, it is required that both images be obtained from the same type of sensor (i. e., both aerial photography). Satellite types supported by *WIARS* include LandSat TM, LandSat MSS, and SPOT. *WIARS* also supports any aerial photography or other type bip formatted data (although vegetative indices are not available). If you have further questions regarding data preparation or need assistance preparing your data for use, please contact the WIARS System Administrator.

<Previous Page> <Next Page> <Table of Contents>

Getting Started

Program Flow

When the user points his or her browser at the WIARS site, the first screen consists of a bar of buttons across the top (See Figure 1) and this button row appears on every major WIARS screen.

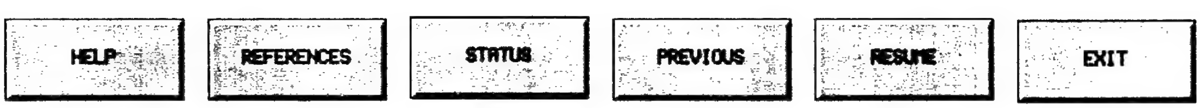


Figure 1 – **Button row on every major *WIARS* screen.**

Before continuing with the program flow, we will discuss how to use this button row.

Help

If the user clicks on the **help** button, a new browser is launched and this document is displayed. Help will be displayed on the topic that relates to the screen currently viewed by the user. Each help page will have a link back to the table of contents, the previous page in the help documentation, and the next page in the help documentation. Detailed information on how to use help is given in the Using Help section of Getting Started.

References

If the user clicks on the **references** button, a new browser is launched and a document containing references to many different aspects of this project is displayed.

Status

If the user clicks on the **Status** button, a new browser is launched and a document containing all work performed to date is displayed. In order to update the status report, the user must click on the status button. The status page is extremely useful for rechecking commands given to *WIARS* and for determining work completed to date. Some of the statistical routines can take a very long time for large data sets, so the user can check status to make sure the program is still running and where in the process it is. The user can check his status even if he has exited the program to see if a process has finished its run. The URL is

```
http://bayesian.shsu.edu/~wiars/<login>/status.html
```

where <login> is the project name (described below).

Previous

The **previous** button allows the user to back up to the previous Main Screen. The previous command was inserted so that the user can return to a previously visited screen and either make changes or clarify commands previously issued.

Resume

The **resume** button allows a user who has logged off to continue at the point of exit. For example, if the user has a large preprocessing job in progress, then he may wish to exit and then log in at a later date to continue the work. The resume button is only enabled on the Screen following Login.

Exit

The **exit** button allows the user to exit the program. The user can login later if there is still work to be done.

Now that we have discussed how to use the button row, let us continue with a description of the program flow. On the initial screen, the user will see the button row, the *WIARS* logo, and two buttons "Login" and "Setup".These buttons allow the user to either login to continue work on a project or to setup a new project.

After the user has entered the setup information or logged in, the program moves to the Download Screen. At the download screen, the user instructs *WIARS* where to look for data to be used in the analysis. *WIARS* returns a listing of data at these sites and asks the user to select the data he wants and then requests additional information about each file selected. Once this information is provided, *WIARS* retrieves the data and moves it to the server machine.

Before moving on to the statistical and mathematical processing of the data, WIARS allows the user to view the data on the Image View Screen. Here, the user can view various parts of the satellite image, create vegetative indices and view them, and overlay masks or GIS layers. The purpose of this screen is to allow the user to investigate properties of the data and to make decisions such as whether to discard various channels of information that may not be useful to him or to clip the region and concentrate on a certain area. The user is also provided with several image processing tools with which to better view the output.

The last step before processing is the Image Clip Screen. As previously mentioned, the user may decide to concentrate on only a portion of the data. The tools on this screen allow the user to clip the data to his specifications. Before exiting the screen, the user also provides information regarding masks to apply and channels/vegetative indices to retain in subsequent analyses

Now that the user has selected exactly the data to be used in the analysis, the program moves to the Preprocessing Screen. At this screen, the user decides which statistical and mathematical routines to be used. The user can choose to enhance the data by utilizing spatial augmentation, create a supervised or unsupervised classification map, or perform change detection/assessment to determine the differences in the two main sets of data.

Once the preprocessing is complete, the program moves to the Output Screen. The output screen is the final screen and it is here the user can view various images that the program has created, generate different files by overlaying images, perform boundary detection on generated images, create movies or slideshows from images, or , if digitized video or video is available, run the GIS Videography Module. After the user has finished he is exited from the program. He can always log in to *WIARS* at a later date and run the output module again.

A flow chart is available for those who wish to see a schematic representation of how *WIARS* works.

<Previous Page> <Next Page> <Table of Contents>

USING HELP

Extensive help is available online with WIARS. The help you are reading now can be thought of as program flow help, but for those interested users, detailed help and flowcharts are available for all of the mathematical and statistical algorithms and the remote sensing applications. These flowcharts are also "clickable" in that you can click on a box in the figure and go to the help related to the topic in the box.

Anytime you click on a hyperlink that connects to another part of this document, you will see a table of contents link, a previous help documentation page link and a next help documentation page link. If you want to go back to the page you previously visited, use the back key on your browser. Several of the main *WIARS* screens have popup dialog boxes. There is no button row on these dialog boxes. If you want help, cancel the dialog and click on the help button at the corresponding main screen.

<Previous Page> <Next Page> <Table of Contents>

Initial Screen

Figure 2 – **The *WIARS* Initial Screen.**

The Initial Screen is where you either login to continue work on an existing project or setup a new project. If you click "Login", and Login popup dialog will appear (Figure 3) and if you click "Setup", a Setup dialog (Figure 4) will appear. These dialogs are described in detail below.

<Previous Page> <Next Page> <Table of Contents>

Login

In order to keep various projects separated and secure, WIARS invokes a login system. The user must provide a login name and a password. The login name is determined during the initial setup and is a name that is comprised of no fewer than three characters and no more than eight characters. The password must be six characters and contain at least one non–alphabetical character (1,$,], etc).

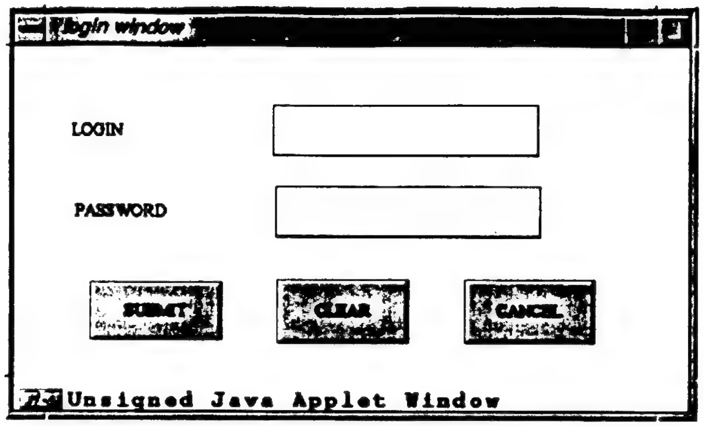


Figure 3 – **The *WIARS* Login Dialog.**

<Previous Page> <Next Page> <Table of Contents>

Setup

In this dialog, the user is asked to provide a login name and a password for the project. Other information is requested both for the user's benefit and in case there is a problem with the program and the system administrator needs to contact the user. The user is asked to re–enter the password. If the password and the re–entered password match, the user is sent back to the Initial Screen (Figure 2) to login. If these two entries are different, the program erases them and the user must re–enter the password information.

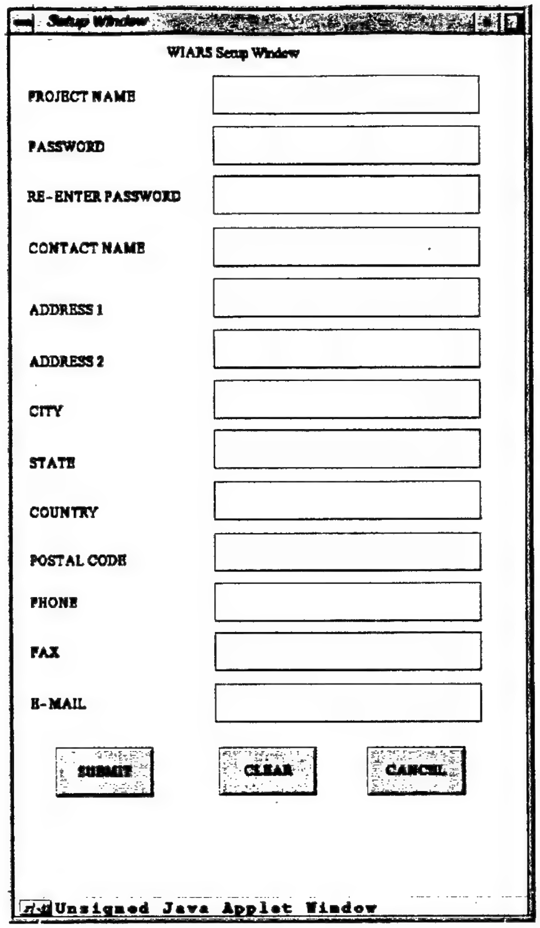


Figure 4 – **The *WIARS* Setup Dialog.**

<Previous Page> <Next Page> <Table of Contents>

Download Screen

After the you have successfully logged in, the next task is to move data to the *WIARS* main server computer. In the Download Screen, you first specify the Universal Resource Location (URL) of the data for the first image and then specify a second URL (it may be the same as the first if all the data is stored in the same place) for the second image. You must have successfully formatted the data (see Data Preparation) and placed it on a machine with an http server (here is a good reference book). Once you have entered two valid URLs, click the **Submit Button**. All data at the URLs you provide appear in list boxes below the submit button. (see Figure 5). Note that not every file appears, rather every file prefix. *WIARS* assumes that with each prefix for raw image and mask/GIS files, there are the three bip, hdr, and bpw files.

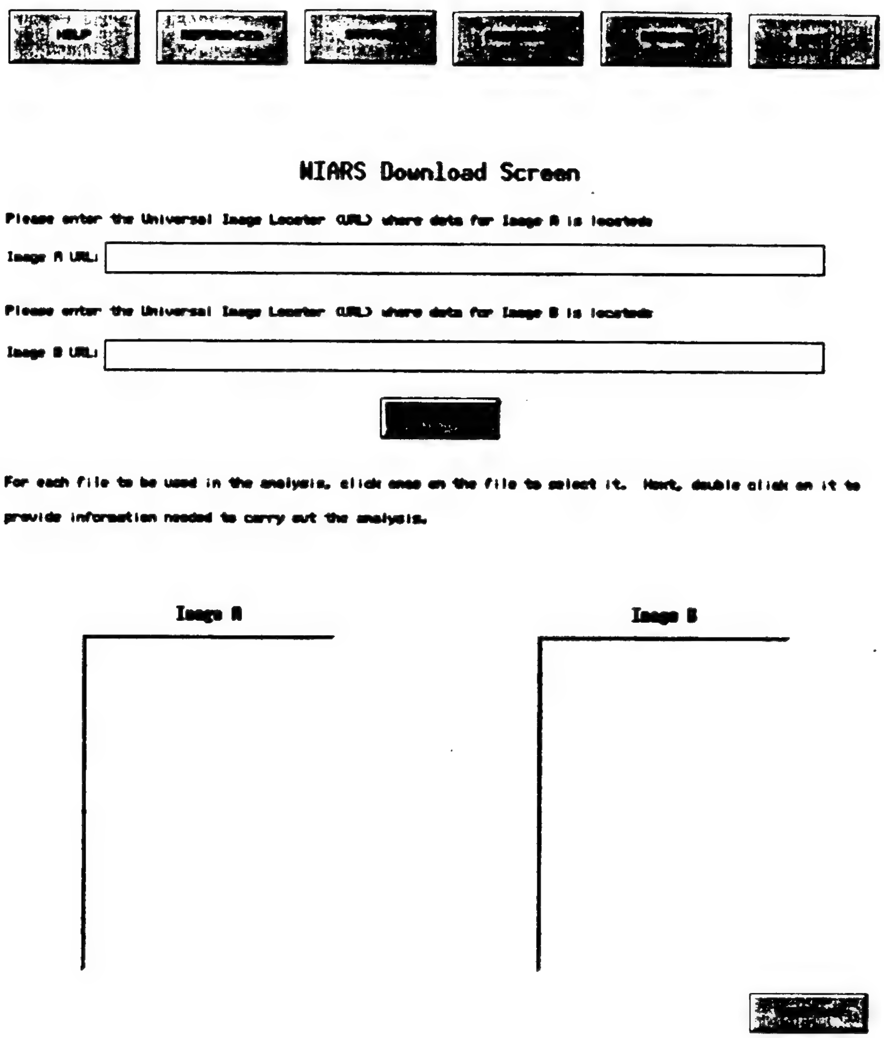


Figure 5 – **The *WIARS* Download Screen.**

The submit button is disabled to prevent against subsequent downloads that might overwrite existing data. If you want to retry, you must click on **Previous** and go back one screen.

Before continuing, it is important that you provide WIARS with some basic information about each file you plan to use. To select a file, click on it once and it is highlighted in black. Now double click on the file to pull up the *WIARS* Image Characterization Dialog (see Figure 6).

<Previous Page> <Next Page> <Table of Contents>

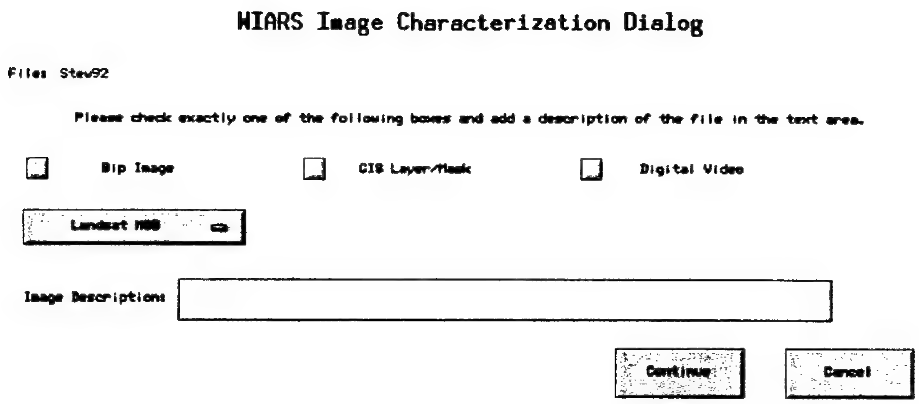


Figure 6 – **The *WIARS* Image Characterization Dialog.**

For each file, *WIARS* needs to know if it is a raw image file, a mask/GIS layer file, or a digital video file. Check the appropriate box to characterize the data in this way. *WIARS* also needs to know how the data was obtained. Select the appropriate choice from the pulldown menu. Currently, *WIARS* only accepts LandSat TM, LandSat MSS, SPOT 1–2, and 3–band aerial photography. Finally, you are asked to enter a description of your data. This is for your benefit and *WIARS* only uses it for a caption of the image in the Output Screen.

<Previous Page> <Next Page> <Table of Contents>

Image View Screen

The **Image View Screen** (see Figure 7) is for the purpose of analyzing the data you have uploaded to the main server. In this screen you can view up to three bands of your images, change colors, overlay masks/GIS layers, view masks only, or view vegetative indices. This screen is here basically so that you can get a feel for your data. If you have already looked at your images, then you can click on **Continue** and move on. Alternatively, you can use this screen to possibly determine channels of information that may not be useful to subsequent analysis or look at vegetative indices that may be used in the analysis.

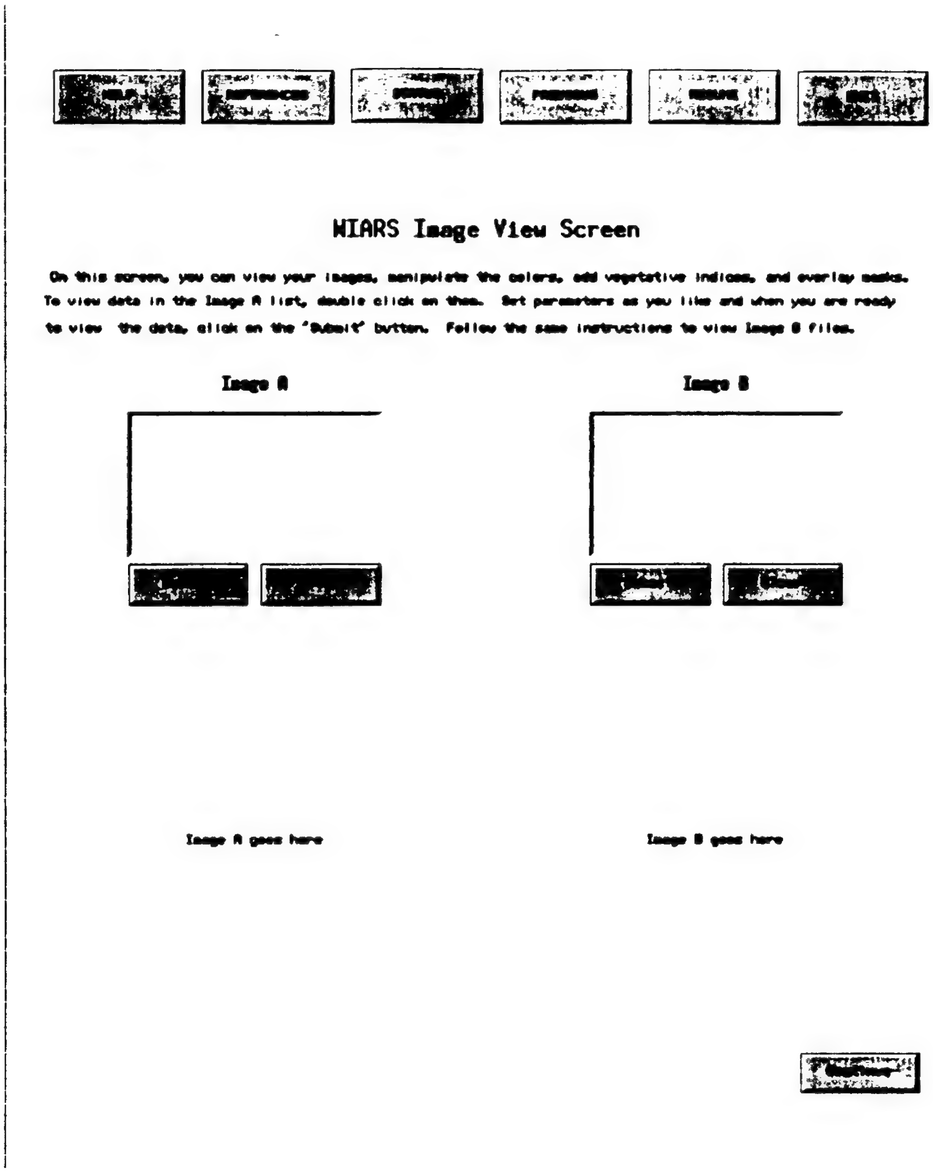


Figure 7 – **The *WIARS* Image View Screen**.

When you first arrive at this screen, you'll notice your raw image and mask files selected in the previous <u>Download Screen</u> visible in the list boxes below Image A and Image B. As a default, if you click on **Submit** under each of the list boxes, you will be shown a picture of the respective image. Alternatively, you can double click on an item in the list box and configure the viewing parameters. Since there are two types of data (raw images and masks/GIS layers), there are two different popup dialogs that might appear.

Image View Configuration Screen

WIARS allows you to do use different image processing tools to manipulate your image so that you can better understand changes that are occurring or interesting areas. These functions are available on the **Image View Configuration Screen** (see Figure 8). A description of each feature is given below:

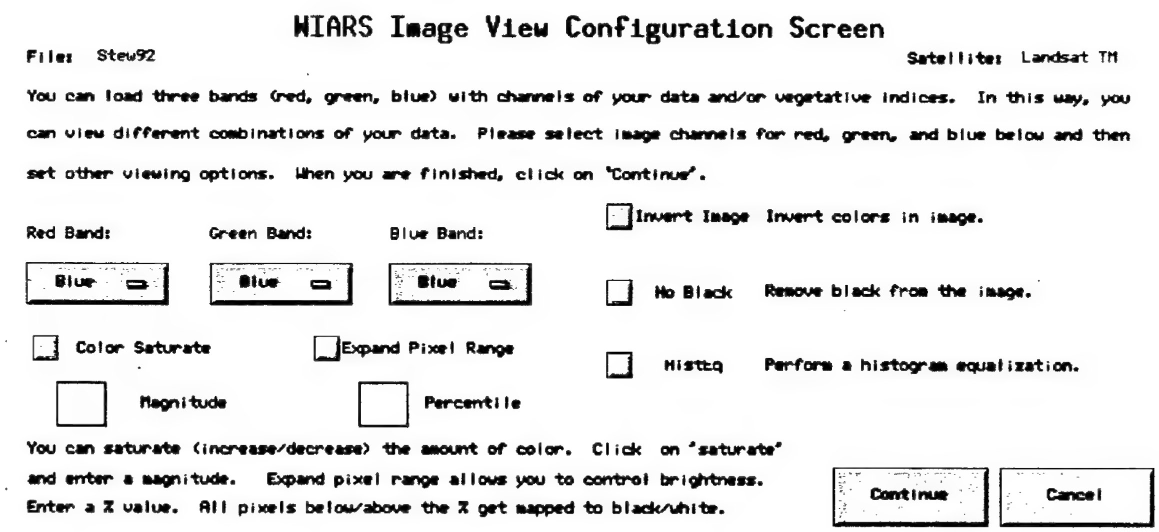


Figure 8 – **The *WIARS* Image View Configuration Screen**.

Image Channels

While your data may consist of more than three channels of information, a color image you see on the browser screen can only consist of three. Therefore WIARS lets you select which three bands you wish to view and you have the option of loading them into any of the image colors (red, green, or blue) you choose. You can even load the same band into all three image channels and produce a greyscale image. Under each image channel WIARS displays the different bands from your chosen satellite (see references for more information) and three vegetative indices. Currently *WIARS* only provides three indices but we plan to add more in later releases. These indices are IR–R (the infrared minus the red channel), the NDVI, and the TNDVI (see the references). You have complete freedom as to how you decide to load the image channels. We suggest you try different combinations.

Image Processing Functions

You can choose to alter the raw data by applying various image processing functions provided by *WIARS*.

Color Saturate – this function allows you to control how much color appears in your image (just like your TV). If you choose color saturate, you must also enter a magnification scale. For example, if you enter '2', then the result will contain twice as much color as the raw data. If you enter '.5', then the result will contain half as much color as the raw data.

Expand Pixel Range – this function allows you to 'stretch' the raw data values. Like color saturate, you must enter a percentile. Suppose you enter 15 for your percentile. Then all the pixels in the range lower than the 15th percentile are mapped to black, all the pixels above the 100–15=85th percentile are mapped to white and the remaining pixels are stretched accordingly. This function allows you to throw out the very dark and very light and accentuate colors in the middle of the spectrum.

Invert – this function simply inverts all pixel values. For example, black becomes white, white becomes black and bright red (all red, no green, no blue) becomes bright cyan (no red, all green, all blue).

No Black – this function simply removes the color black from the result image.

Histogram Equalization – this function allow you to equalize colors. You can think of this as analogous to your contrast button on your television set. Use this function if you want to accent certain areas that you think are not showing up very well.

When you are finished loading your image channels and configuring image processing functions, click on continue. You will be returned to the Image View Screen an here you can configure other files.

<Previous Page> <Next Page> <Table of Contents>

Mask View Configuration Screen

You can also decide whether to overlay masks and configure them in the **Mask View Configuration Screen** (see Figure 9).

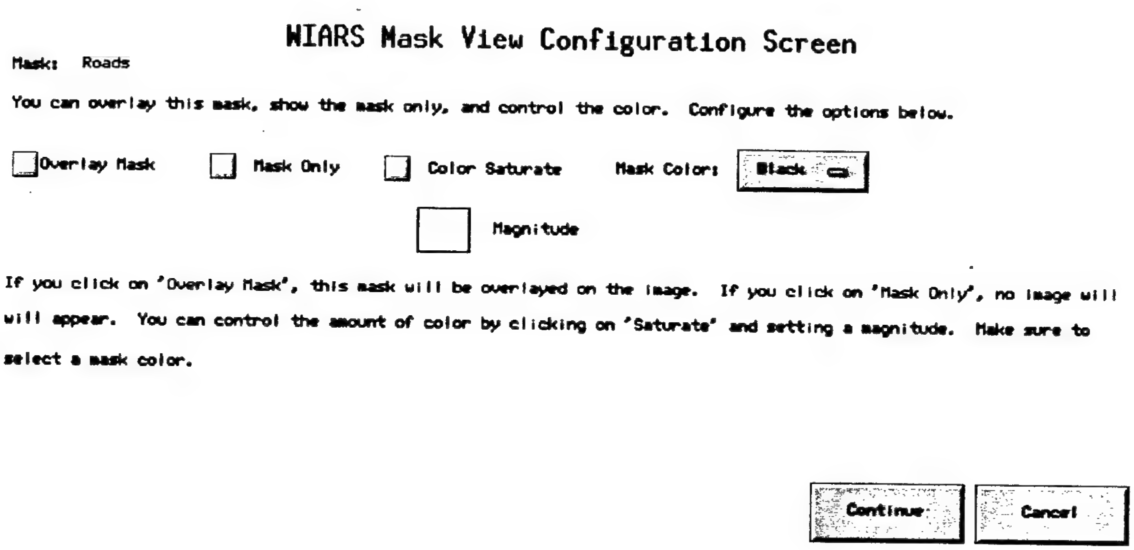


Figure 9 – **The *WIARS* Mask View Configuration Screen.**

The primary function of this screen is to allow you the opportunity to overlay the mask displayed in the upper left hand corner. Click on the **Overlay Mask** if you wish to overlay the mask. Other options are described below

Mask Only – Click this button if you wish to show only this mask and no image. If you click it for one mask then it carries over to all masks and no raw image will appear.

Color Saturate – This function works just like the color saturate in the Image View Configuration Screen.

Mask Color – This function allows you to pick a color for the mask. Choices are Black, Red, Green, Blue, Cyan, Purple, Yellow, and White.

Click on **Continue** when you are finished.

Image View Screen Functionality

Now that you know how to choose images and masks, you can use this **View Screen**. Once you have configured the image and masks for either of Image A or Image B, click on the appropriate **Submit** button. The image and its overlays as you have configured them appear below the file list. You can go back and select an image or a mask, reconfigure it, and click on **Submit** as often as you like. When you are finished viewing the images, click on **Continue**. At this point, you should know enough about your data that you can answer the questions that appear in the Band/Mask Selection Screen.

<Previous Page> <Next Page> <Table of Contents>

Band/Mask Selection Screen

Before continuing to the Image Clip Screen, you must provide information regarding which channels of information should be used in the subsequent analysis and which masks should be used as data exclusion masks. The layout of the screen is shown in Figure 10.

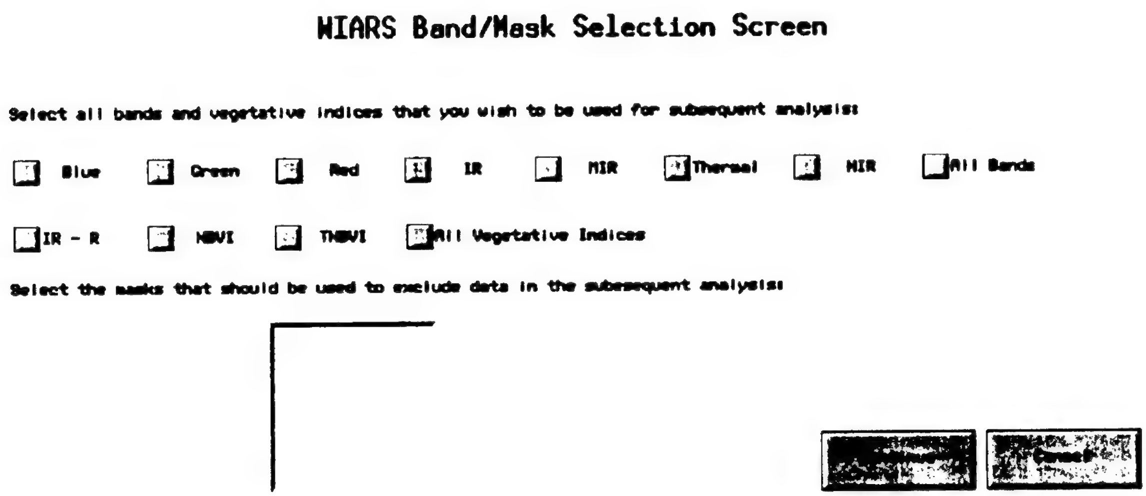


Figure 10 – **The *WIARS* Band/Mask Selection Screen.**

The first thing you should do is check the channels from your original data that you would like to include in the subsequent analysis. You can check all if you wish. You can also add vegetative indices. Remember, the subsequent analysis basically involves detecting and assessing change, and creating classification maps, so make sure to include only data you wish to use.

Below the checkboxes, you will see a list of all masks. From these you will form an *exclusion mask.* An exclusion mask will basically exclude portions of the raw data you have selected from the analysis. For example if you add a "roads" GIS layer to the exclusion mask list, then any pixels that correspond to roads locations will not be used in the analysis. Click once on a mask in the list to select it. Click again to unselect it.

WIARS will create a new raw data set based on your channel selections (and renumber the bands accordingly) and create a new masks by merging all the masks you have selected. Hit continue when you are finished and wish to proceed.

<Previous Page> <Next Page> <Table of Contents>

Image Clip Screen

The last screen before preprocessing is the **Image Clip Screen**. Since you may not want to use the entire satellite data you provided, *WIARS* allows you to clip the sceens. Actually, you clip only Image A and the same clip is performed on Image B. The clip routine WIARS provides does not make use of geographical coordinates described in the bpw files in the Data Preparation Help. Rather you are shown your image and given the number of rows and columns in the image and then prompted to crop rows and columns off of the top, bottom, left and right. Figure 11 shows the **Image Clip Screen**.

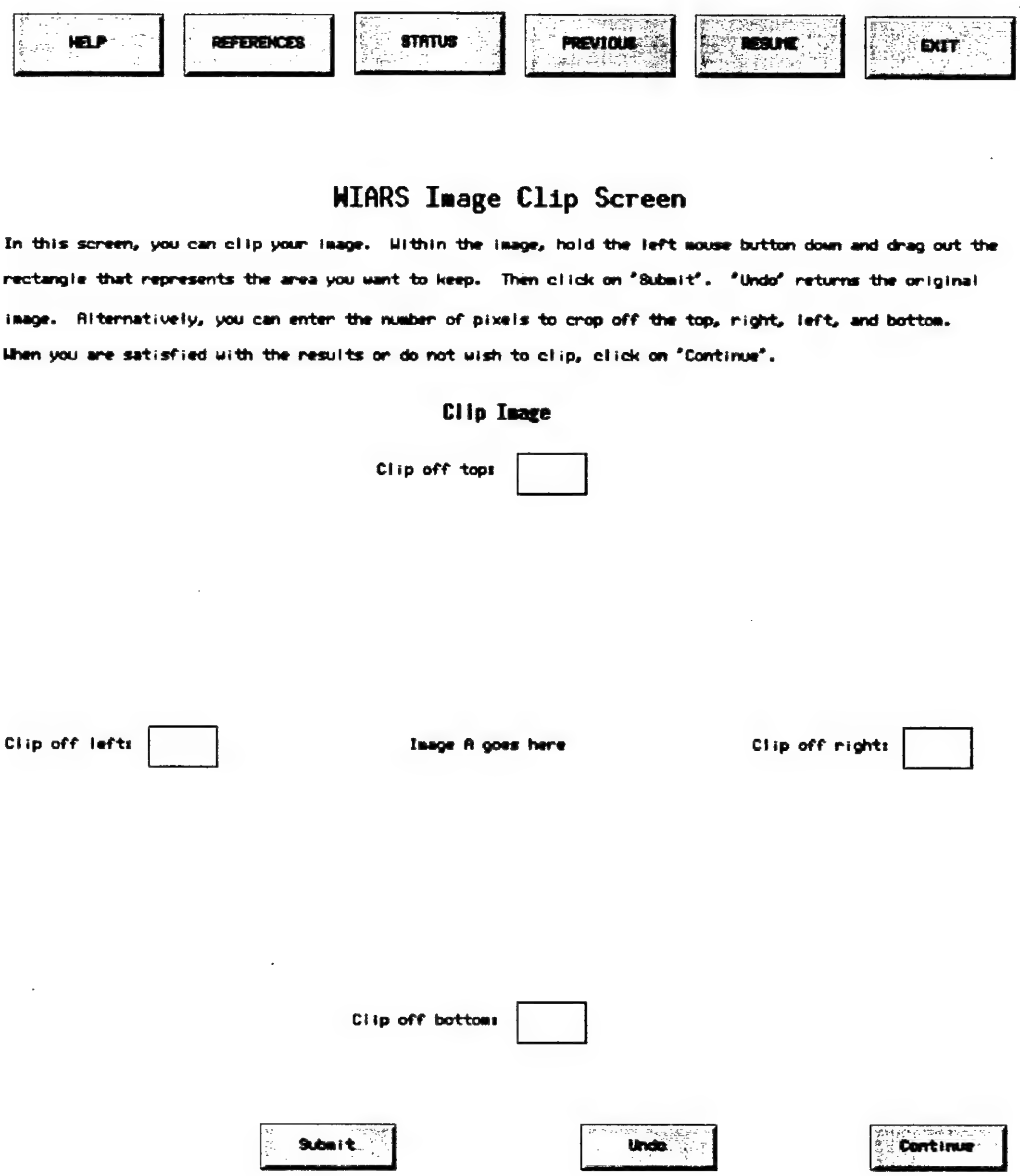


Figure 11 – **The *WIARS* Image Clip Screen.**

The image will appear in the center of this screen and you have the option of either entering the rows and columns you want clipped or using the mouse to hightlight the region. To use the mouse, place it in the upper left hand corner of the box you want to keep. Hold down the number one mouse button (usually the left button) and drag a box to the lower right corner of the box. Once you let off the mouse button, a rectangle appears. Click on **Submit** to clip whether you have manually entered the values or used the mouse. **Undo** will return the image to its original dimensions.

After you hit **Submit**, a new image appears in the center of the screen. This image is the original image with the part you clipped away illustrated in a greyscale and the part you outlined shows up in its original color.

You can clip, **Submit**, and **Undo** as often as you like. Once you are satisfied with your result, click on **Continue**.

Important Note: Once you hit continue, your image will be clipped to the last image that appeared in the center of this screen. If you do not want to clip or just keep your original image, make sure to click on **Undo** before you **Continue**.

<Previous Page> <Next Page> <Table of Contents>

Preprocessing Screen

At this point, you have basically uploaded your data and manipulated image. The Preprocessing Screen (Figure 12) allows you to apply some mathematical and statistical routines to your data.

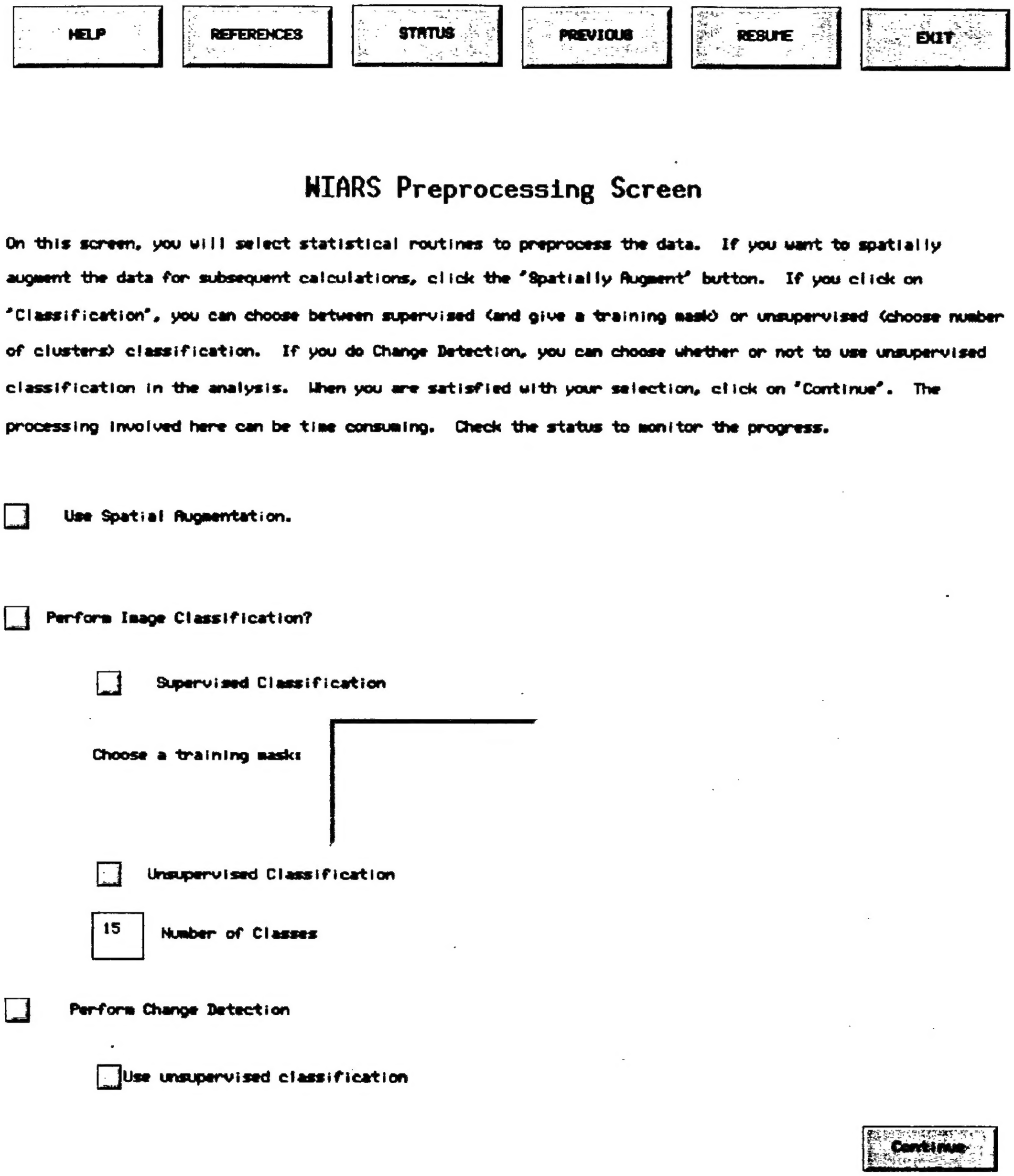


Figure 12 – **The *WIARS* Preprocessing Screen.**

The screen is divided into three parts and each is designed to perform a task that will prepare your data for the final output screen that follows. The three tasks are outlined below:

<Previous Page> <Next Page> <Table of Contents>

Spatial Augmentation

Pixels in images are very often spatially correlated. That is, in images, pixels are typically very much like their neighbors. *WIARS* allows you to exploit this fact and preprocess your data with **spatial augmentation.** Extensive help and a flowchart depicting how the spatial augmentation module works is available here. Additionally you need to know that spatial augmentation will add N extra bands to a data set that originally consisted of N bands. Therefore your output data that you can manipulate on the next page will consist of twice as many bands as before. Spatial augmentation has been shown (see references) to improve performance in classification and change detection so we strongly suggest you toggle it on. The downside to augmentation is that it creates a larger data set that will slow computation speed.

<Previous Page> <Next Page> <Table of Contents>

Unsupervised Classification

Unsupervised classification is a routine that attempts to classify your data into various clusters. Extensive help and a flow chart for unsupervised classification is available here. Currently, *WIARS* only performs one type of unsupervised classification routine, but we plan to allow more choices in the future. You are asked to provide the number of clusters the routine is supposed to produce.

<Previous Page> <Next Page> <Table of Contents>

Supervised Classification

Supervised classification is a routine that tries to locate pixels by use of a training mask. For example, suppose a training mask is provided that illustrates known red cockaded woodpecker habitats. First supervised classification attempts to form a signature of all image pixels that correspond to those in the mask and then tries to locate all other pixels in the image that resemble the signature. Extensive help and a flow chart for supervised classification is available here. You are asked to click on one of the masks you uploaded to use as a training mask.

Classification Note: At this point, *WIARS* only allows one supervised classification job per run. If you wish to perform another supervised classification, you need to click on the Previous button in the **Output Screen** and reset the training mask.

<Previous Page> <Next Page> <Table of Contents>

Change Detection/Assessment

The final statistical tool available on the Preprocessing Screen is **Change Detection/Assessment**. This routine will compare the two images you have uploaded and attempt to locate where change has occurred and to what extent it has occurred. The preprocessing done here allows you to investigate the severity of change in the **Output Screen**. Extensive help and a flow chart of the change detection/assessment module is available here. The only decision you need to make regarding change detection is whether or not to use unsupervised classification in the process. Unsupervised classification has been shown to improve change detection in some cases (see references). However, many times the improvement is negligible and is not worth the additional computation time.

<Previous Page> <Next Page> <Table of Contents>

Output Module